INDUSTRIAL ACCIDENT PREVENTION

Industrial Accident Prevention

A Scientific Approach

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PREFACE

Since the first edition of this book was published in 1931, there have been additional opportunities to check the effectiveness of the methods that are advocated. They have been proved to be sound in principle and practicable of application. That which was at one time regarded as theory is now recognized as fact. It is commonly admitted that the great majority of industrial accidents are caused directly by specific unsafe acts of persons or exposure to specific mechanical or physical hazards. It is agreed that these causes and the accidents that they create interfere seriously with the quality, volume, and cost of production and are of a preventable nature. There is general agreement, also, that successful methods in accident prevention are similar to those that are used in controlling production and, therefore, that industrial management is well equipped to solve its employee-safety problems. In addition, there has been a remarkable increase of public interest in the conservation of life and property. During this period the average person has become more safety-conscious. His interest has spread from traffic safety, where it was largely centered, to safety in industry. Employers, especially, realize far more clearly that accident prevention is a profitable combination of humanitarianism and common-sense good business policy.

The interest thus created results in a demand for more information relating to practical methods of preventing accidents and has led to the decision to publish this revised edition of "Industrial Accident Prevention."

Changes have been made in the revised text for the purpose of achieving greater consistency, clarity, and improved arrangement. The treatment of the subject has been enlarged and modernized with regard to illustrations and text. In no way, however, has there been any alteration of the fundamentals on which the original publication was conceived.

The new arrangement is orderly and logical and is especially adapted to textbook purposes. It is directed to industrial executives, personnel managers, safety directors, safety inspectors and engineers, supervisors and foremen, and students of business management and insurance, as individuals, and to instructors who are engaged in teaching classes of such individuals.

The chronology and historical background of the industrial-safety movement are given in appendixes. The essential principles of accident prevention are described in the first chapter, thus providing a narrative picture of modern accident-prevention methods in condensed form and in one section. Chapter II describes the basic philosophy that underlies the treatment of the subject in subsequent chapters. The three chapters that follow are devoted to an explanation of the practical work of accident prevention in manufacturing plants, construction work, and other industrial activities. Further development of the various phases of the subject and specific illustrative examples are found in succeeding chapters.

Fundamentals of accident prevention are featured, and method is emphasized more than detail because, if the method is basically correct, satisfactory results must eventually follow its practical application even though the details of procedure may differ.

When accident prevention is resolved into the principles stated in the text, it appears, and actually is, simple.

The author is indebted to The Travelers Insurance Company for the opportunity to obtain the data and experience required in the preparation of the text. Acknowledgment is also extended to Mr. Edward R. Granniss, director of the Industrial Engineering Division, National Conservation Bureau, and to Mr. Elliot P. Knight, superintendent, Engineering Department, The Employers Liability Assurance Corporation, Ltd., for their cooperation. Mr. Granniss and the Industrial Division of the National Conservation Bureau assisted generally in this new edition and provided the material for the "Chronology" and

"Background of Industrial Safety" given in the appendixes. Mr. Knight fathered the chapter on "Occupational Disease." Mr. George H. Bartholomew, editor of *The Travelers Standard*, assisted generously in the work of editing.

The cooperation of the U. S. Department of Labor, The National Safety Council, and the many individuals and organizations specifically referred to in the text is also greatly appreciated.

H. W. HEINRICH.

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INDUSTRIAL ACCIDENT PREVENTION
A SCIENTIFIC APPROACH

CHAPTER I

PRINCIPLES OF ACCIDENT PREVENTION

The principles of modern and successful industrial-accident prevention are well set forth in the following summary of a recent executive conference. This incidentally is typical of situations that have occurred in many progressive manufacturing concerns.

The executive vice-president called into his office the production manager, the treasurer, and the insurance manager, for the purpose of considering a report that had been received from the service engineer of the compensation-insurance carrier. In this instance it was the responsibility of the insurance manager to handle the correspondence and he therefore was asked by the vice-president to read and comment on the report.

He explained that the submittal was in two parts, one being an introductory letter and the other a plan for the prevention of accidents. It was his understanding that under the terms of his policy contract the insurance company assumed responsibility for losses. The statement made in the very first paragraph of the letter, to the effect that the manufacturing company was paying *because of accidents* more than $100,000 annually in addition to the normal compensation premium, came therefore as something of a shock. A further statement in the introductory letter was likewise startling. This stated that if the executives were interested in reducing the total cost it was wholly reasonable to expect that a 50 per cent reduction could be made in one year with the probability of lower insurance rates and a smoother and more economically functioning plant.

At that point the treasurer interrupted to inquire as to the relation between the insurance premium and the additional sum of $100,000, since it was his impression that the plant cost was limited to the amount of the policy premium. This led to a discussion of the so-called "hidden" or incidental costs of accidents, of which all members of the conference had heard or read but which had impressed them as being mostly theory and not necessarily applicable to their own case. The production manager volunteered the statement that considerably more than theory was involved. He recalled several conversations with the service engineer of the insurance carrier and admitted that the occurrence of a personal injury frequently involved much more in the way of cost than the payment of compensation and medical bills. As illustrations, he referred to the cost of hiring and training new employees, to the lost time of employees other than the person injured, to overhead cost that goes on while injured persons are absent, to breakage of tools, spoilage of material, interference with or delay in production, loss of goodwill, and an almost endless sequence of consequences, all of which are unproductive and expensive.

Further discussion developed that the insurance service engineer had arrived at the figure of $100,000 by applying a four-to-one ratio to the annual direct cost of injuries to the employees, this being an average ratio which was developed through exhaustive and authentic research.

A lively interest was then expressed as to whether their own particular plant was an average case and could therefore justifiably be assumed to have an incidental accident cost as huge as quoted. The production manager was of the opinion that the statement was justified and added that the reason it made so forceful an impression was probably because for the first time a belief that had been long held with regard to manufacturing concerns in general was now being translated into a specific amount in dollars and to their own concern. He recalled that since the publication of the four-to-one ratio in 1926, confirmation of its accuracy had come from many sources as a result of practical application. In cooperation with the plant cost department, the insurance service engineer had analyzed a sizable cross section of accidents and injuries and had found, much to the surprise of the production manager, that the ratio was actually more than four to one. The production manager recalled an injury that occurred in the plant's pressroom and entailed heavy tool-repair bills. In this case, the employee had inadvertently tripped a press while using a metal rod to remove punchings and had bruised his hand. Incidentally, the dies were ruined, and replacement cost over $180, whereas the direct cost of the injury was but $2 for one visit to the doctor. Even more striking, however, were the hidden costs of many injuries for which the insurance company *paid absolutely nothing.* Lost-time or compensable injuries were relatively infrequent. There were, however, approximately thirty minor bruises, cuts, and scratches for every more serious injury, and the incidental cost of these alone, in a year's time, was more than half the amount of the entire premium.

Following these revelations, the discussion logically turned to available facts as to what was wrong and to a consideration of practical corrective action.

The vice-president made the following statement:

We have apparently been too self-satisfied. We have been too content with inadequate and ineffective methods. Our compensation-insurance rates have increased and our employees continue to get hurt. Hidden accident cost may be expressed as nearly 5 per cent of our payroll or 10 per cent of our *annual direct material* cost. Heretofore we have considered our time well spent in giving executive attention to the reduction of the costs of items that were as low, in some cases, as one-half of 1 per cent of the total cost of raw material. I am not sure that our hidden accident cost is so great as has been estimated. The insurance engineer says it is $100,000. Maybe it is more; maybe it is less. I am satisfied that it is heavy enough to warrant executive attention. We want happy satisfied workers, and we want to eliminate accidental injuries, anyway, even if such injuries cost us nothing whatsoever. It is fortunate, however, that we now have a tangible business incentive to urge us to action. I had thought that we were doing all that was reasonably possible to prevent accidents, but the second section of the report puts a new light on the subject. Read it aloud, if you please.

The insurance manager read as follows:

The reports of injuries resulting from accidents that occurred during the year just completed have been analyzed, a complete survey of your plant has been made, and accident causes have been selected. We find that more than 80 per cent of all your accidents result from three conditions. *These conditions still exist* and will produce more injuries if not corrected.

In order to set them forth explicitly and to direct attention to the specific points where action should be taken, we present the following list:

A. Employees in Building B walk under suspended crane loads in willful disregard of posted instructions.

B. Aisle markings are not observed by employees when piling material throughout the plant. Although this is contrary to specific instructions, it is more directly the result of improper planning for available storage space, the lack of which makes it inconvenient for the employees to follow safe-practice rules.

C. Employees are unaware of safe lifting postures and lift heavy loads while in awkward and unsafe positions.

At this point the vice-president interrupted to say that he had heard enough to indicate the general nature and scope of the report. He inquired of the production manager if it were a fact that the instructions referred to were actually disregarded as stated. It was admitted that the statements were true and that the extent of disregard had been sufficient to cause many injuries. The insurance manager now referred to a statement in the service engineer's report, to the effect that the employees were none too keenly interested in safety work and were not convinced that the plant management itself was greatly concerned.

Inquiry was now made as to whether the safety instructions were of an impractical nature; in short, whether there was any good reason why they should not be followed. It was admitted that poor observance was largely due to man failure, first on the part of the workmen, and second on the part of the foremen. This led to a further conclusion by the vice-president to the effect that in addition to these points of failure the situation as described constituted a friendly and constructive *indictment of the entire staff*. Summing up, he said:

This report, in effect, states the real and specific causes of our accident troubles. In addition, it names certain reasons why our employees act unsafely. These circumstances have not only produced most of our past injuries but they still exist and are likely to cause further trouble. We know now what these conditions are and where they are. We all admit that they should not exist. As far as I can see, we must use exactly the same methods that we already employ to correct unsatisfactory conditions regarding *quality and volume of product.* First of all, we must let it be known that the management of this plant believes in safety and expects safe performance in all respects. The actual enforcement of safe-practice rules and the correction of mechanical hazards are primarily responsibilities of the supervisory staff.

The production manager then said that inasmuch as the cause of accidents indicated man failure, he proposed to place responsibility squarely on the superintendents and through them on the individual foremen, who in the final analysis were paid because of their ability to handle men. In addition, he planned to follow through personally on the basis of the report, until the results, as shown by reduced accident frequency and severity, were satisfactory.

The insurance manager and the treasurer, who had followed the conversation intently, expressed their desire to cooperate and to be kept advised of the development and effectiveness of the accident-prevention program. Progress reports from the insurance carrier were considered desirable.

The vice-president further remarked:

There is no need to set up an elaborate system of red tape. Let's accept the plan that has been offered, get these progress reports as suggested and put accident prevention on the agenda for our regular monthly meetings hereafter. It appears to be merely an incidental part of our routine work, although a very important one. The production department will be expected to get results. In return for salary and wages expended, we have a right to expect of our foremen that they so conduct their departments that our product will be turned out not only in satisfactory volume and quality but with safety as well. We have able foremen and every confidence that they can control accident frequency and costs, once we have made it clear that we expect them to do so, particularly because it is evident that the causes of our accidents are clearly of the same type as those that result in defects and interference with production.

The meeting was then adjourned. It had lasted exactly 15 minutes and was often referred to afterward as one of the most profitable periods, considering its duration, that the executive committee had ever spent.

Of course the accident record in that plant was improved. From the very first, there was no question as to results, because it was evident that with full knowledge of real accident causes and with the means available to eliminate them, the outcome was practically certain.

Hidden costs up to 50 per cent of the previously existing amount were saved. The insurance premium was steadily reduced, and, best of all, fewer employees suffered disabling and painful injury.

Fundamental Principles.—The above example is given because it illustrates what may be accomplished through application of the three basic principles of scientific accident prevention. These are:

1. The creation and maintenance of active interest in safety.
2. Fact finding.
3. Corrective action based on the facts.

In common with practically all industrial problems, including those dealing with production, sales, cost accounting, quality of product, etc., the principles listed above are applicable to problems resulting from industrial-accident occurrence. In the solution of *any problem* it is obviously necessary that there be a sufficient degree of active interest; first, in order that the problem be recognized, and, second, that it be solved. In the process of solving a problem of any kind, the essential facts must of course be determined, after which a remedy is selected and applied. If that remedy is to be practical and effective it must invariably be based on the essential facts as previously determined.

In the particular example cited, an active interest in accident prevention was created, and the essential facts were provided by the insurance engineer whose report also proposed practical corrective action based on the facts. Management then proceeded to put the corrective measures into effect with most happy results.

Brief Explanation of Principles.—Inasmuch as the general nature and scope of the text of this book are directly affected and controlled by the knowledge that there are underlying principles in the work of industrial-accident prevention, it seems advisable to explain those principles:

1. *The Creation and Maintenance of Active Interest.*—The purpose of the text is first to show that the creation and maintenance of interest are necessary as an initial and a continuing procedure in effectively conducted safety work; second, to explain what is meant by interest; and third, to provide detailed information sufficient to indicate how interest may be created and maintained.

This principle of industrial-accident prevention is discussed more fully in Chap. III where details and examples are given. At this point, however, it will be informative to state that the prevention of industrial accidents requires an all-inclusive interest, by which is meant that management as well as workers must be interested to such a degree that they will actively participate in any safety program that is set up. As will be explained in subsequent chapters, the responsibility for accident prevention rests primarily upon the shoulders of management. However, in view of the fact that both management and employees are concerned, and because of the difference in status of these two groups, the work of creating and maintaining interest varies in nature, scope, and methods of application. For example, management will be more interested than the individual workers in the direct and also in the hidden cost of accidents. Both management and the worker are interested in the humanitarian aspects of safety. Appeals to pride, skill in workmanship, and loyalty are more effectively applied to the worker than to management, whereas the effect of accident occurrence on volume and quality of production appeals more to industrial executives than to employees in the lower wage brackets.

Finally, it should be recognized not only that interest is a vital factor in the practical control of accident occurrence but also that the creation and maintenance of interest cannot be left to chance. In short, effective methods must be devised and applied that are suited to the particular industry and that can be depended upon to produce satisfactory results.

2. *Fact Finding.*—The second principle of modern industrial-accident prevention, itemized herein as "fact finding," refers to the assembling of essential information bearing first of all upon accident occurrence and finally upon accident prevention. The work of fact finding is of such fundamental importance that Chap. IV has been devoted to an explanation of it. With regard

to accident occurrence, it is necessary to know who was injured, the time and place of the injury, the severity and often the cost of the injury, and the type of the accident and the injury. The foregoing, of course, are merely facts of identification. For accident-prevention purposes it is necessary to know how and why the accident occurred and, in particular, the specific personal unsafe act, together with the reason for its commission and the specific mechanical or physical hazard, if one existed. In addition, and depending upon the degree of interest, available time, the seriousness of the problem, and the investigator's knowledge and ability, many facts other than those already referred to are of interest and value and should be obtained. This refers to the nature and kind of work being performed at the time of the injury, the department where the accident occurred, the machine or other agency involved, the physical condition and often the mental condition of the employee, facts relating to "before-and-after-the-whistle-blows" environment, the previous employment and accident history of the injured employee, and many other kinds of related information. In this book, the attempt is made to distinguish between the facts that invariably are essential and others that are helpful but are not always essential. Realizing that the complete ideal program of accident prevention awaits the millennium, it would seem advisable and necessary to treat the subject of fact finding exactly as the entire subject of industrial-accident prevention is treated herein; namely, to emphasize its principles and what may be termed its absolute essentials.

3. *Corrective Action Based on the Facts.*—It logically follows that the actual direct work of preventing accidents is the final step, which requires, first of all, the creation and maintenance of interest and which must be governed by the facts of the particular problem in question. If, for example, the interest of management results in finding that workers slip and fall on greasy floors, it is clear that any corrective action that is devised should be related to these particular facts. More specifically, the interest of management would probably lead to the disclosure of facts in addition to the ones already mentioned. Investigation would undoubtedly be made to find out why grease was spilled on the floors and probably, too, why it was not cleaned up. Further investigation might delve into situations related to safe footwear,

abrasives and other nonslip materials, floor coverings, light, methods of lubrication and of handling grease and oil, condition of bearings, etc. Notwithstanding the variations and complexities of situations and the unlimited possibilities of investigation, it remains true that, in one degree or another, any corrective action that is finally determined upon should be based on available and pertinent facts.

The third principle of industrial-accident prevention, therefore, is fully as axiomatic as the first two; and it can be said in defense of all three, that they are as truly applicable to problems in general as they are to industrial-accident prevention.

Theory and Practice.—Management may have entire confidence that the accident-prevention methods herein advocated are practical and may be applied successfully. As a matter of fact, they are not based on theory as much as on time-proved practice. They represent an orderly and logical sequence of steps that have been taken successfully in the past and are now being taken wherever satisfactory results are more than fortuitous.

In many instances accident-prevention methods are adopted without conscious selection, sound reasoning, or knowledge that they fit the case to which they are applied—and very often they work satisfactorily.

In one case of record the general superintendent of a large construction company issued and followed up a single executive order and thereby reduced his accident frequency and cost over 30 per cent. Becoming alarmed because of the rising trend of accident experience, he called a meeting of all superintendents, their assistants, and the foremen and stated in no uncertain terms that *he wanted them to stop accidents.* The order was repeated several times, records were kept, and responsibility was placed. Despite the fact that there was no knowledge of accident causes, no safety organization, and no specific educational work, satisfactory results were achieved.

A sales manager succeeded in increasing sales by the simple method of injecting his personality into the matter in a most forceful way. He held a series of meetings at which he demanded of his salesmen that they *"go out and bring in the orders or else."*

In countless other cases, however, these methods *do not succeed.* The sales manager who simply demands that his salesmen produce results, while at the same time he is totally unaware that deliveries are delayed, competitor's product is better and less expensive, commissions are lower than average, and salesmen are inexperienced or incompetent, would be more likely to increase sales volume if he knew these conditions and adopted methods based on his knowledge. The industrial executive likewise, who in the example cited obtained satisfactory results by the issuance of a single forceful order, would be more likely to succeed in reducing the number of accidents in his plant if he were better informed as to accident causes and remedies.

No-injury Records in American Industry

Company	Industry	Injury-free man-hours
A	Tobacco	12,957,095
B	Chemical	11,361,846
C	Machinery	11,114,600
D	Glass	7,243,532
E	Textile	6,792,695
F	Metal products (miscellaneous)	6,442,278
G	Sheet metal	5,808,921
H	Rubber	5,688,369
I	Steel	5,326,144
J	Nonferrous metals	4,955,909
K	Automobile	4,729,000
L	Public utilities	4,337,640
M	Petroleum	4,216,600
N	Laundry	4,174,257
O	Tanning, leather	4,149,174
P	Meat packing	4,054,449
Q	Food	3,904,841
R	Cement	3,579,883
S	Paper and pulp	3,343,623
T	Construction	3,079,500
U	Printing, publishing	2,716,151
V	Woodworking	2,298,758
W	Foundry	2,034,419
X	Quarry	1,809,965
Y	Marine	1,525,140
Z	Mining	1,243,854

The conservation of human life, the prevention of economic waste and interferences with industrial production emphasize the need of substituting planned effort for "cut-and-try" methods.

The appearance of theory may be associated with the procedures advocated herein largely because they have been named and defined, related to one another and to the safety problem as a whole, explained and illustrated. In reality the recommended methods are so simple and direct as to be elemental. The task of accident prevention as outlined can be expressed as "finding, naming, and correcting the conditions and circumstances that cause accidents."

The reason for adding detailed explanation lies in the fact that "finding" requires cause-analysis, that "naming" can only be done as a result of cause-analysis and "correcting" necessitates the selection of remedies that are based on cause-analysis.

In short, the author's primary purpose is to advocate the application of *selective* methods instead of those chosen by guess and without careful thought as to their probable value.

It Can Be Done.—Outstanding safety-performance records show not only that "it can be done" but also that "it is being done." The plant records shown in the table on page 10 are quoted from "Accident Facts," 1941 edition, National Safety Council, Inc.

Inquiry regarding the methods used by these concerns in accident prevention indicates that, in part at least, they followed the outlines that are featured in the text. In some cases the methods were more elaborate; in others they were less so. Further, the emphasis on particular phases of analysis and corrective action was sometimes based more on personal preference than on disclosed fact, but in practically all cases the principles of creating and maintaining interest, fact finding, and corrective action were recognized and applied.

CHAPTER II

BASIC PHILOSOPHY OF ACCIDENT PREVENTION

SECTION 1

This chapter is of an explanatory and preliminary nature. Having agreed upon the three underlying principles of industrial-accident prevention, as outlined in Chap. I, it follows that the most practical and effective means of applying those principles toward accomplishing the desired objectives should now be described. The reader will observe that the methods that are advocated in subsequent chapters, although wholly conventional, are not selected at random but follow a consistent pattern. This is because they are based on axioms that constitute a basic philosophy of industrial-accident prevention. The following list itemizes these self-evident truths.

Axioms of Industrial Safety

1. The occurrence of an injury invariably results from a completed sequence of factors—one factor being the accident itself (see Section 2).
2. An accident can occur only when preceded by or accompanied and directly caused by one or both of two circumstances—the unsafe act of a person and the existence of a mechanical or physical hazard (see Section 2).
3. The unsafe acts of persons are responsible for the majority of accidents (see Section 3).
4. The unsafe act of a person does not invariably result immediately in an accident and an injury, nor does the single exposure of a person to a mechanical or physical hazard always result in accident and injury (see Section 4).
5. The motives or reasons that permit the occurrence of unsafe acts of persons provide a guide to the selection of appropriate corrective measures (see Section 5).
6. The *severity* of an injury is largely fortuitous—the *occurrence* of the accident that results in the injury is largely preventable (see Section 4).
7. The methods of most value in *accident prevention* are analogous with the methods required for the control of the quality, cost, and quantity of *production* (see Section 6).
8. Management has the best *opportunity* and *ability* to prevent accident occurrence, and therefore should assume the *responsibility* (see Section 7).
9. The foreman is the key man in industrial accident prevention (see Section 7).

10. The *direct* costs of injury, as commonly measured by compensation and liability claims and by medical and hospital expense, are accompanied by *incidental* or *indirect* costs, which the employer must pay (see Section 8).

In view of the influence that these axioms have on the text in succeeding chapters, it is appropriate to offer certain substantiation and enlargement.

SECTION 2.—THE ACCIDENT SEQUENCE[1]

The Five Factors in the Accident Sequence.—A preventable accident is one of five factors in a sequence that results in an injury.

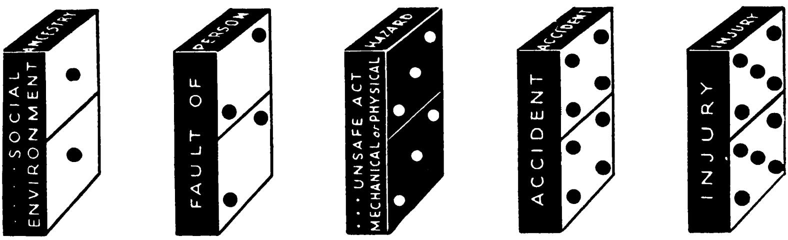


FIG. 1.—The five factors in the accident sequence.

The injury is invariably caused by an accident and the accident in turn is always the result of the factor that immediately precedes it.

In accident prevention the bull's eye of the target is in the middle of the sequence—an unsafe act of a person or a mechanical or physical hazard.

The several factors in the accident occurrence series are given in chronological order in the following list:

Accident Factors	Explanation of Factors
1. Ancestry and social environment.	Recklessness, stubbornness, avariciousness, and other undesirable traits of character may be passed along through inheritance. Environment may develop undesirable traits of character or may interfere with education. Both inheritance and environment cause faults of person.

[1] Extracts from an address presented before the Down River Section of the Detroit Safety Council, Nov. 30, 1934, by the author.

Accident Factors	Explanation of Factors
2. Fault of person.	Inherited or acquired faults of person; such as recklessness, violent temper, nervousness, excitability, inconsiderateness, ignorance of safe practice, etc., constitute proximate reasons for committing unsafe acts or for the existence of mechanical or physical hazards.
3. Unsafe act and/or mechanical or physical hazard.	Unsafe performance of persons, such as standing under suspended loads, starting machinery without warning, horseplay, and removal of safeguards; and mechanical or physical hazards, such as unguarded gears, unguarded point of operation, absence of rail guards, and insufficient light, result directly in accidents.
4. Accident.	Events such as falls of persons, striking of persons by flying objects, etc., are typical accidents that cause injury.
5. Injury.	Fractures, lacerations, etc., are injuries that result directly from accidents.

The occurrence of a preventable injury is the natural culmination of a series of events or circumstances, which invariably occur

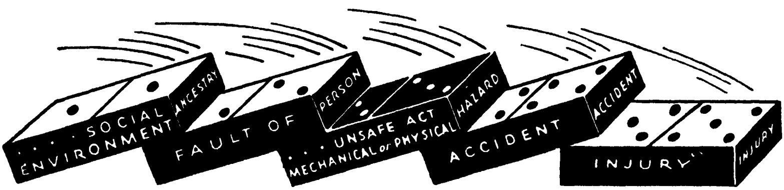


Fig. 2.—The injury is caused by the action of preceding factors.

in a fixed and logical order. One is dependent on another and one follows because of another, thus constituting a chain that may be compared with a row of dominoes placed on end and in such alignment in relation to one another that the fall of the first domino precipitates the fall of the entire row. An accident is merely one link in the chain.

If this series is interrupted by the elimination of even one of the several factors that comprise it, the injury cannot possibly occur.

Definition of Accident.—At this point it is advisable to consider what is meant by the term "accident." Students of safety and many persons actively engaged in supervising safety activities misunderstand the relation between the accident itself and the other factors in the accident sequence. There are but a limited number of true accidents as these are defined in this text. "Struck by" is a typical event that meets the definition of accident given herein. Note that to describe an event as "struck by," is of itself sufficient to indicate the kind of accident that occurred. It is informative to indicate who was struck, what the object was that struck the injured person, why the object fell or moved, why the injured person exposed himself to injury, the extent of the injury, and many other facts of interest; but the simple phrase "struck by" still remains fully descriptive of the *accident* itself. In successful safety work it is necessary to distinguish clearly between the several facts of accident occurrence and especially to segregate the accident per se from the other factors in the sequence of which it is a part.

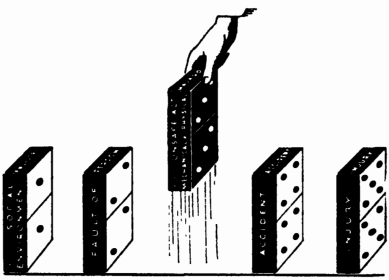


Fig. 3.—The unsafe act and mechanical hazard constitute the central factor in the accident sequence.

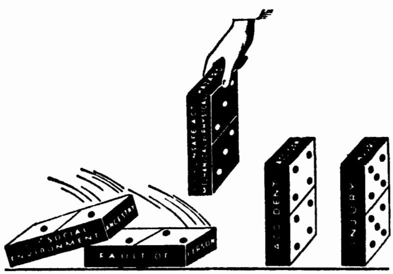


Fig. 4.—The removal of the central factor makes the action of preceding factors ineffective.

An accident is an event in which (*a*) the contact of a person with an object, substance, or another person, or (*b*) the exposure of a person to objects, substances, other persons or conditions, or (*c*) the movement of a person, causes personal injury or suggests the probability of such injury.

NOTE.—The treatment of the subject in this text is confined to "personal-injury accidents," including occupational disease. It is of interest to note, however, that *property damage*, with or without personal injury, results from identical accident types and that prevention of property damage is attained by applying the methods herein specified for accident-injury prevention.

Science in Accident Prevention.—Accident prevention can be portrayed as a science and as a work that deals with facts and natural phenomena. It is a problem that may be solved by the same kind of reasoning that is successfully applied to many other problems concerning which there seems to be a better general understanding.

The accident-prevention engineer is interested in all the accident factors but is not directly concerned with all of them. His work relates primarily to the accident and its prevention. Consequently his activities should center upon the factors immediately preceding the accident itself; these being the unsafe act and/or the mechanical hazard, and the proximate reasons why these exist.

Happily, the first event or circumstance in the list of factors does not always result in establishing the series that produces an injury. Many things may occur to break the chain. A person having inherited or acquired faults may not act unsafely or may not permit a mechanical hazard to exist. If he does violate a safe-practice rule it is possible that an accident may not occur. Even when a person falls or is involved in some other kind of an accident, there may be no resulting injury. Most important, too, is the fact that supervision and management may control the actions of employed persons and prevent unsafe acts and may guard or remove mechanical hazards even though previous events and circumstances are unfavorable. However, when and if an injury does occur it is invariably the result of the preceding complete series of factors.

Practical Application of the Factors in the Accident Sequence. Knowledge of the factors in the accident sequence guides and assists us in selecting a point of attack in prevention work. It permits simplification without sacrifice of effectiveness. It also permits expansion of safety work into the underlying field of human behavior and affords opportunity for the application of general educational plans, with a more complete knowledge of exactly what should be done and why it should be done. In short, the factors in the accident sequence constitute an index of the kind of information the accident preventionist must deal with if he is to perform his work efficiently.

If one single factor of the entire sequence is to be selected as the most important, it would undoubtedly be the one indicated by the unsafe act of the person or the existing mechanical hazard. No preventable accident has ever occurred or ever will occur without the existence of one or both of these circumstances. A great deal of effective safety work can be done, therefore, even if application of accident-prevention measures is restricted to these two points alone.

A typical accidental injury may serve as an illustration. Assume that an employee in a manufacturing plant receives a fractured skull as the result of a fall from a ladder. Investigation discloses that he descended the ladder with his back to it, in willful disregard to instructions, and caught his heel on one of the upper rungs. The effort to train and instruct him and to supervise his work was not effective enough to prevent this unsafe practice. Further inquiry also indicated that his social environment was conducive to the forming of unsafe habits and that his family record was such as to justify the belief that reckless tendencies had been inherited.

Here is a chain of circumstances and events that tie in with one another in unmistakable fashion. If ancestry and social environment had been free from criticism, it is probable that the injured person might have had a safer and better attitude and would have been more subject to control through supervision. If supervision has been more effective, the employee might not have committed the unsafe act even though he was inherently inclined to be reckless. If the unsafe act had not been committed, assuredly this particular accident would not have occurred, even if all the preceding factors had tended to promote it; and if the accident had not occurred there could have been no injury.

It is clear from this listing of factors that there is a central point of attack in practical accident-prevention work. When an injury has occurred it becomes a matter of history, and so, too, does the accident. Prevention must deal with the immediate conditions and circumstances out of which other similar accidents may be created. Common sense dictates that preventive effort be directed toward the thing most easily and quickly corrected. Referring to the analogy between the list of accident factors and the row of dominoes shown in Fig. 4, it is clear that in the case of an accident and injury resulting from an unsafe act, the unsafe act immediately precedes the accident; and, if it is removed from the line, the action of any one or all of the factors that precede the accident will be ineffective. Therefore, the logical direction of safety work should be toward the elimination of similar unsafe acts. It is reasonable, furthermore, to proceed toward the correction of the unsafe act by directing attention to the factor immediately preceding it; that is, the reason for its commission, and from then on to dig into the background of the accident only so far as may be necessary to accomplish results. Similar action is indicated for the prevention of accidents that are caused primarily by unguarded machines or other mechanical or physical hazards.

SECTION 3.—MAN VS. MACHINE

The most ardent supporters of the belief that man-failure accident causes are predominant are, nevertheless, firmly convinced that mechanical guarding and correction of mechanical and physical hazards is a fundamental and a first requirement of a complete safety program. They believe, and act on the belief, that safety begins with safe tools, safe machines, safe processes, and safe environment. This attitude is not at all inconsistent with the emphasis placed herein on the importance of man failure as a causative factor, and is more readily visualized when one considers "corrective action." In the same breath it can be truthfully said that although man failure *causes* the most accidents, mechanical guarding and engineering revision are nevertheless important factors in *preventing* the most accidents.

It has been known in a general way, for a number of years, that physical hazards were becoming less important as a factor in accident causation, but there is no evidence that the extent of this diminution has been measured by authoritative research. The causes and cures of the majority of industrial accidents have not been clearly and definitely fixed, nor has the extent of preventability been determined.

This criticism would indeed be nonconstructive if nothing more helpful could be added to it. Progress has recently been made, however. The origin of industrial accidents has been successfully traced within practical limits, with the result that much has

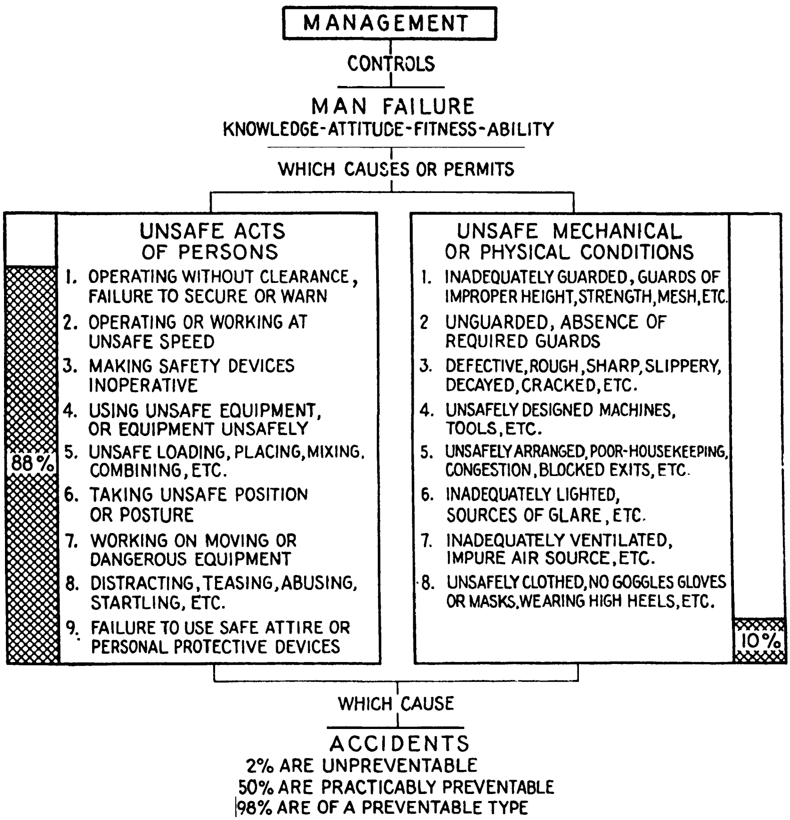


FIG. 5. Chart of direct and proximate accident causes.

been proved that heretofore has only been suspected. In addition, the discovery has been made that the actual facts exceed expectations.

Figure 5 shows graphically the results of research into the causes of accidents. It is amplified and explained in the following paragraphs.

Twelve thousand cases were taken at random from closed-claim-file insurance records. They covered a wide range of territory and a great variety of industrial classifications. Sixty-three thousand other cases were taken from the records of plant owners. Through analysis of these 75,000 cases, through study of actuarial records and engineering reports, and with the cooperation of employers, it was found that 98 per cent of industrial accidents are of a preventable kind.

It was discovered that 25 per cent of all accidents would, according to usual but improper methods of analysis, be charged to defective or dangerous physical or mechanical conditions, but that in reality the causes of many accidents of this group were either wholly or chiefly man failure and only partly physical or mechanical. This group, therefore, was found actually to be 10 per cent instead of 25 per cent. This difference (15 per cent) added to the 73 per cent of causes that are obviously of a man-failure nature, gives a total of 88 per cent of all industrial accidents that are caused primarily by the unsafe acts of persons.

In this research major responsibility for each accident was assigned either to the unsafe act of a person or to an unsafe mechanical condition, but in no case were both personal and mechanical causes charged.

In addition to the research that resulted in the development of the above ratios, other studies have been made, one of chief interest being that conducted by the National Safety Council. This showed unsafe acts for 87 per cent of the cases and mechanical causes for 78 per cent. An analysis made in 1940 of cases reported by the state of Pennsylvania showed an unsafe act and a mechanical cause for an *equal number of accidents.* One reason for the difference in the number of accidents charged to personal or mechanical causes in the three studies described above is that in the last two the method permitted both kinds of causes to be assigned for the same accident, whereas in the study first mentioned only the cause of major importance was assigned.

Admittedly, judgment must be used in selecting the major cause when a mechanical hazard and an unsafe act both contribute to accident occurrence. Personal judgment may lead to error, but it is defensible and necessary and in the majority of cases results in fair conclusions.

For example an employee may be injured by the flying fragment of a burst grinding wheel that was but partly inclosed, because in complete disregard of instructions he attempted to snag a heavy casting on a wheel that was designed for light tool work only.

The grinding wheel could have been more fully guarded, yet it will be agreed generally that the unsafe practice was primarily at fault.

Therefore, when judgment of this kind is used in selecting major accident causes the results substantiate the conclusions of the first-mentioned research to the effect that unsafe practices cause more accidents than mechanical hazards.

The report[1] of the Bureau of Research on Information of the Pennsylvania Department of Labor and Industry entitled "1939 Statistical Supplement of Industrial Injuries in Pennsylvania" is illuminating. This report, according to the bureau, is based on data tabulated under a modification of the Heinrich Cause Code, adopted in Pennsylvania in January, 1938. Provision is made in this code for the separate tabulation of one unsafe act and one mechanical cause for *each* accident; however, the matter of assigning chief responsibility to either cause is one for the local plant or other accident source to take care of. With the above explanation in mind, it is of interest to note that the total number of recorded unsafe acts in the state of Pennsylvania for 1939 was 99,264 and the total number of mechanical causes was 99,093, out of a total number 103,607 accident injuries. Clearly, the indications are that in the majority of cases there is both a personal and a mechanical contributing cause. Just as clearly, both kinds of causes should be eliminated as far as is practicable.

Referring again, however, to the research from which it is asserted that personal unsafe practices directly cause the majority of accidents, attention is directed to the fact that although two causes exist, one often is more directly responsible than another. An example will serve to make the point clear:

A worker who has been instructed to turn in worn and unsafe tools and under no circumstances to use unsafe tools, nevertheless

[1] See Appendix for excerpts from "1939 Statistical Supplement of Industrial Injuries in Pennsylvania."

retains in his possession a badly mushroomed chisel. He uses it and a piece of the burred head flies off, strikes and injures his cheek. To be sure a mechanical hazard is a cause of the accident. More important, however, from the viewpoint of practical safety in this instance is the personal cause—using unsafe tools—and also the personal subcause—willful disregard of instruction. It is by means of such reasoning that the majority of industrial accidents are charged to man failure rather than to mechanical fault.

From still other studies varying results have been secured, but all agree in general that man failure is predominantly the outstanding proximate and direct cause of industrial accidents.

Mastery of Machine.—Future historians may refer to the twentieth century as the crest of the machine age or as the beginning of a phase of its newer and stronger development. Whatever the future may hold, we of today live, work, play, and die in a machine age. But we do not die nor are we hurt primarily because of machine fault.

Mechanical, electrical, and chemical hazards beset us on all sides; from above and from below. The home, transportation, and industry are largely mechanized. The symbols of mechanical power surround us; belts and pulleys, gears and wheels, explosives and chemicals, high speed, high pressure, and power are the playthings, the tools, the apparent necessities, and the conveniences of today. Yet the machine is less harmful than the actions of man.

About 34,500 men, women, and children were killed in automobile accidents, 17,000 in industry, and 33,000 in homes, in 1940. Neither machines nor mechanical devices can justly be blamed for the great majority of these deaths.

Over 1½ billion horsepower is generated, for various purposes, in the United States. In the ten years from 1929 to 1939, it increased more than 19 per cent, and is likely to continue to increase. In a single machine, logs may be converted to matches or toothpicks and be packaged and labeled ready for the consumer. Another machine draws plain paper from an immense roll and in two seconds produces a printed newspaper, with its pages cut and folded to proper size and arranged in numerical order, ready for the public with news of births and deaths, gangster warfare, conventions, society, sports, and politics.

Man is surrounded by this maze of power and machinery, and the consequent toll of death is appalling—yet the machine itself cannot be held at fault.

A costly high-powered automobile carrying six persons crashed into the rear end of a heavily loaded truck. Two persons were killed and four others were seriously injured. The driver of the automobile was a scatterbrained youth seventeen years of age. He and his companions had been drinking. The car was speeding at more than 60 miles an hour, at night and with lights dimmed. The boy had passed such rudimentary examination for a driver's license as the state laws required, just three days before the accident. The taillight of the truck was obscured by dirt. Was machinery at fault?

An explosion killed three men at work in a quarry. The operations were highly mechanized. Compressed-air rock drills, gasoline-powered shovels, blasting machines, and high explosives were used. Four of five charges had exploded. The fifth had failed to go off. Everyone on the job, from the foreman to the helpers, knew the dangers of the situation. They knew that a suitable time interval should be allowed to elapse before approaching the unexploded charge and that other precautions should be taken. Despite this common knowledge, two of the men proceeded immediately to examine the wiring. No one thought to call them back. There was no necessity for haste. The men had everything to lose by it and nothing to gain. The delayed shot went off when they had barely started their inspection. They and another workman lost their lives. Can this justly be blamed on mechanization of industry?

In a period of six months, two little girls lost their lives under identical conditions, in a garage equipped with heavy-duty elevators. The elevators were used to hoist automobiles from the street level to an upper storage space. The public was forbidden to ride. In each case the owner of the car and his little girl disobeyed the rules. In each case the child was allowed to play around the elevator while the parent attended to the storage of the automobile. The elevator-shaftway walls were constructed with "setbacks" so that recesses or openings were formed between the car platform and the walls. Both children fell through these openings.

Local building laws prohibited such construction. Inspectors had strongly urged protection, but their recommendations had been disregarded. Shall we rest content with charging the fault to the machine age?

A huge steel-framed building was being erected. The usual evidences of mechanization existed in the form of trucks carrying steel beams and stone, and of derricks, hoists, riveting hammers, and suspended working platforms. A nearsighted laborer wheeled a barrow overloaded with brick along a platform high in the air. No screen was provided to catch falling objects. The platform had no toeboard at its outer edge to keep unsecured material from falling off. Someone had left loose pipe lying on the platform. The planks of the platform were uneven and were not fastened in place. The laborer, in trying to push the wheel of the barrow over the end of a plank, stepped on the loose pipe, slipped, and overturned the entire load of brick into the street below. A woman was struck by one of the falling bricks, and her skull was fractured. Two other persons were painfully injured by the falling bricks. Is it fair to say that machinery or mechanization was at fault?

A workman lost his life in a steel-rolling mill. He was engaged in oiling the bearings of a mill capable of producing 5,000 tons of steel rails a day. Not understanding the value of protective devices, he removed a portion of one of the gear guards, reached in, and was caught and killed. Four other workers and a foreman stood close by. Were industry and the machine responsible?

Instances such as these are not rare. Rather, they typify accident occurrence. Differing only in the nature of the work performed, the machinery involved, the extent and severity of injury, and the specific kind of unsafe act or circumstance, hundreds of thousands of fatal and nonfatal but serious injuries occur in this country annually. Man—not machine—is at fault.

To be sure, extraordinary hazards exist chiefly because of the introduction of machines. And it is true, further, that many serious and perplexing problems, social and economic, arise because of mechanization. These problems necessitate adjustments that are often costly. In the final analysis, however, it must be admitted that man invented the machine, built it, and put it to work. He alone gave it life and motion. It moves when and where he directs, at the speed he desires, and stops when he stops it or when the energy he gave it expires.

The high-powered automobile in which the two young persons were killed, as described in the first example, was but a beautifully finished and inoffensive ornament as long as it stood in the garage. Man turned on the ignition. Man forced down the accelerator. Man drove it recklessly until it crashed into another vehicle.

The machine is dangerous as man makes it so. It is the use of the machine—more correctly, the abuse of it—that creates danger.

Nor is the appalling degree of man failure fully portrayed by its direct results in loss of life, limb, and dollars. Willful disregard of instructions, recklessness, violent temper, and lack of knowledge or training result in unsafe acts for many of which no penalties whatever are exacted in the form of personal injuries or property damage. For example, automobiles left unsafely parked on grades run wild through busy streets and crash into buildings, and no one is hurt. Steelworkers "ride the ball" and are hoisted hundreds of feet into the air in the erection of skyscrapers, yet they do not always fall. Guards on heavy machines are removed, men stand under suspended loads, get on and off moving vehicles, leave obstructions in walkway areas, pile material insecurely, refuse to wear goggles, gloves, masks, and other protective equipment, and yet injuries are relatively infrequent.

The situation reminds one of an honestly conducted lottery where most of the tickets fail to draw anything, whereas a certain fraction of them draws small prizes, and a still smaller fraction draws big ones. In the case of the lottery, however, the prizes are hoped for and desired, whereas in the accident situation the case is the reverse. It is hard to understand why those who have been in the habit of playing lotteries are so confident that the occasional event certainly will come to pass once in so often, whereas in the accident field, where the mathematical principles involved are so closely similar, men seem to feel an equal degree of confidence that the occasional event never will come to pass.

It would appear that the laws of chance provide a substantial safeguard. No one individual, however, knows whether he will pay the penalty for the first or the last or some intermediate unsafe act. The moral is to profit by the opportunity to learn, to realize that repeated violations of common-sense safe practice eventually and invariably lead to injury, and to avoid or prevent repetition of them.

With regard to the accidents that occur from automobiles on the streets and highways, the remedy is one of engineering, education, and enforcement, with emphasis on education.

With regard to industrial accidents, the remedy is also one of engineering, education, and enforcement through supervision, but with profitable emphasis on enforcement and supervision, because the employer-employee relationship makes possible supervisory control of employee selection, instruction, and performance.

If knowledge is power and if accidents arise primarily out of the unsafe acts of men, then power in the conservation of life against the ravages of accidents must come first from adequately aroused interest and then from knowledge of specific acts of persons and the reasons why those acts are committed.

SECTION 4.—FOUNDATION OF A MAJOR INJURY

Accidents—Not Injuries—the Point of Attack.—Analysis proves that for every mishap resulting in an injury there are many other similar accidents that cause no injuries whatever. From data now available concerning the frequency of potential-injury accidents, it is estimated that in a unit group of 330 accidents of the same kind, 300 result in no injuries, 29 in minor injuries, and 1 in a major or lost-time injury. The accompanying diagram graphically portrays the net result of this research.

Accident prevention has been, and is to an extent even now, based largely upon an analysis of the causes leading to a major accident. This situation exists, for the most part, because of a misunderstanding of what an accident really is. As a rule, precise terminology is of relatively small importance, except when it is found that it indicates misdirection in both thought and action. Then, the matter of words or phrases becomes decidedly important.

Throughout industry, reference is made to major and minor accidents. The two are definitely segregated. No-accident contests and campaigns are usually based upon lost-time or major-accident frequency. Tables and statistics feature lost-time accidents (or others in the so-called "major group") that involve fatalities, fractures, dismemberments, and other serious injuries;

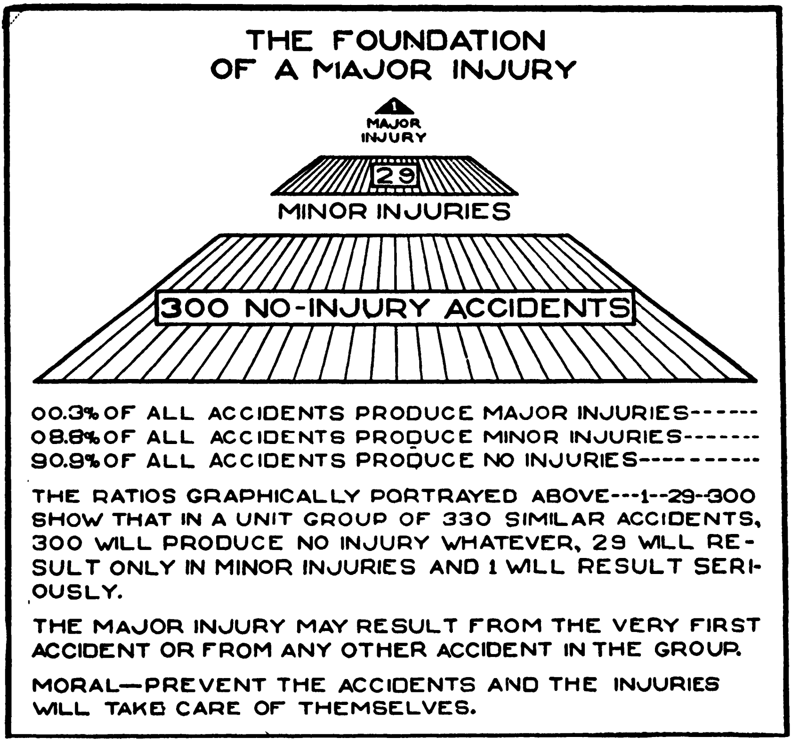


FIG. 6.—The foundation of a major injury.

and, in general, attention is centered upon these more spectacular occurrences to the exclusion, in part at least, of adequate consideration of minor accidents. Not only is this true with regard to cause-and-type analysis and tabulation, but subsequent action in prevention work follows along the same line and is based upon a relatively small number of major accidents.

The expression "major or minor accidents" is misleading. In one sense of the word there is no such thing as a major accident.

There are major and minor injuries, of course, and it may be said that a major accident is one that produces a major injury. The accident and the injury are, however, distinct occurrences; one is the result of the other, and in the continued use of the expression "major accident," and in the acceptance of its definition as one that results seriously, there is a decided handicap to effective work. In reality, when the terms "accident" and "injury" are so merged, it is assumed that no accident is of serious importance unless it produces a serious injury. Yet thousands of accidents having the potentiality of producing serious injuries do not so result. There are certain types of accident, of course, where the probability of serious injury may vary in accordance with circumstances. For example, a type of accident such as a fall, if occurring on a level field of soft earth or on a rug-covered floor in the home, may not be potentially so serious as the fall of a steel erector on the top of a skyscraper. Yet, the former may, and often does, result in a severe injury.

In any case, in prevention work, the importance of any individual accident lies in its potentiality of creating injury and not in the fact that it actually does, or does not, so result. When lost-time or so-called "major" accidents are selected for study, therefore, as a basis for records and for guidance in prevention work, efforts are often misdirected, valuable data are ignored, and statistical exposure is unnecessarily limited.

An injury is merely the result of an accident. The accident itself is controllable. The severity or cost of an injury that results when an accident occurs is difficult to control. It depends upon many uncertain and largely unregulated factors—such as the physical or mental condition of the injured person, the weight, size, shape, or material of the object causing the injury, the portion of the body injured, etc. Therefore, attention should be directed to accidents rather than to the injuries that they cause.

Further, in the length of time over which experience is analyzed (usually from one month to one year), the average plant, or department of a plant, does not develop sufficient exposure to justify the use of the comparatively small number of serious injuries, either as an indication of progress in accident-prevention work or as a safe guide to the real causes of the predominating types of accident.

In basing accident-prevention work upon the cause-analysis of major injuries alone, therefore, not only is the importance of the accidents that produced them overestimated, and the field of research thus limited, but the resulting data also are seriously misleading when used to determine the proper corrective action to be taken. These facts become readily apparent when it is recognized that the major injury does not always result from the first accident in the series of which it is a part. It may occur as a result of the last accident or at any intermediate point, or it may be the result of an exceptional isolated accident type that might never occur again. Basic truths determined by averaging a sufficient spread of data are always of greater value than assumptions having a basis in isolated cases selected chiefly because they are spectacular.

Some years ago, in a certain community close to the water front, more than one thousand persons became ill within a period of a week, and one person died. An autopsy held over the deceased indicated uremia, probably aggravated by impure food, and the circumstances pointed to shellfish as a cause of the trouble. The authorities acted promptly, but not until several other persons had become seriously ill was it discovered that the first fatality was not indicative of the real cause of the epidemic: As a matter of fact, the town water was polluted.

This incident illustrates two points:

First: The real source of the majority of ills is a better guide to action in case of an epidemic than is the source of an isolated case that may be selected chiefly because it is spectacular, or because it results seriously.

Second: An ailment of any kind, whether it is of major or minor gravity, is potentially serious; and the indications of the greater volume of minor cases are vitally significant in the treatment of plagues and epidemics and as a guide to the safeguarding not only of the individual but of the community as well.

The existing situation in the work of preventing accidents is somewhat similar. The occurrence of accidents is frequent enough to warrant comparison with plagues or epidemics. When fatalities or serious injuries occur in industry courts of inquiry are held, state authorities require reports of compensable cases, and, in general, attention is concentrated upon these serious injuries, while the vastly greater volume of minor cases, whose significance as a whole is more pointed, is practically ignored.

Much has been said of near accidents—meaning those that produce no injury whatever, although having the potentiality of doing so. These improper occurrences—these defects, slips, and fumbles; these near accidents—because of their proportionately greater volume, present to the capable person who is intelligent enough to take advantage of it, a splendid opportunity to anticipate and prevent actual injuries.

The number of such no-injury or potential-injury accidents in comparison to actual accident injuries has always been a nebulous quantity, and it probably will never be known exactly. Nevertheless, a minimum has been established which in itself is so high that it proves conclusively the necessity for supervisory control enforced through adequate executive action. It substantiates the belief that the foreman is the key man in industrial accident-prevention work. It ties in even more closely and forcibly the relation of profitable production and accident prevention, since the real causes of accidents are likewise the real causes of decreases in efficiency, production, and profits and denote conditions that are morally and economically improper.

In view of these facts, it should be obvious that present-day accident-prevention work is misdirected when it is based largely upon the analysis of major injuries.

Injuries vs. Accidents.—That this picture is not overdrawn may be better realized when it is considered that in the unit accident group (330 cases) shown on the accompanying chart, under the caption the "Foundation of a Major Injury," a major accident is any case that is reported to insurance carriers or to the state compensation commissioner and that the great majority of these reported or major accidents are not fatalities or fractures or dismemberments; they do not all involve lost time, nor are they all lost-time accidents on account of which compensation is paid. Considering all these facts, it may readily be deduced that an analysis as to cause and remedial action, based upon one accident resulting in a fatal or lost-time or permanent injury (or so-called "major-accident case") out of a total of 330 similar accidents all of which are capable of causing injuries, is limited and misleading.

The truth of this deduction is strikingly demonstrated through the discovery that the frequency of major injuries varies directly with the frequency of no-injury or potential-injury accidents. This result would naturally be expected to follow, since the predominant causes of no-injury accidents are, in average cases, identical with the predominant causes of major injuries—and incidentally of minor injuries as well.

The determination of this no-injury accident frequency followed a most interesting and absorbing study. The difficulties can readily be imagined. There were few existing data on minor injuries—to say nothing of no-injury accidents. Case after case was discarded because of lack of information. Many others were included at a one-to-one ratio (first accident produced an injury), although in all probability there had been dozens, or perhaps hundreds, of previous no-injury accidents. Nevertheless, each injury case was included, where there was any substantial indication of the existence or lack of prior accidents.

It was also necessary to place a practical limitation upon the data. For example, an injury resulted from a mechanical defect. This defect had existed throughout the life of the machine. Over a period of several years, each revolution of the machine had exposed the operator to an injury. Finally, the exact balance of variable circumstances occurred, and an injury resulted. This did not fall within practical limitations and was rejected. In other rejected cases employees were assigned to work for which, by temperament and ability, they were unsuited and were ultimately injured as a direct result. Here, again, are potential injuries, but they are too intangible to record in print. In determining the ratio of 329 no-injury accidents to one major accident injury, only actual visible evidences of man failure that resulted in narrow escape from injury—such as dropping or fumbling of tools or other objects, and falls of persons—were included, and practically all accidents caused by machines were excluded, even though the latter would have raised the no-injury frequency materially.

It needs but little thought for the average person to conclude that the no-injury accident ratio herein expressed is not exaggerated. How many drivers of automobiles would care to assert that they had never had narrow escapes from injury when driving across railroad grade crossings without being absolutely sure that no train was coming, when cutting in and out of traffic, when attempting to beat the traffic lights, when passing cars on grades and hills or when, because of momentary inattentiveness, they were surprised by the sudden appearance of a pedestrian or another car directly ahead and dangerously close? And when accidents and injuries do so occur, what would probably be the ratio of accidents or narrow escapes from injury to actual injuries? When an employee in a plant stumbles, falls, and sustains an injury, is it reasonable to say that he never stumbled or fell before?

No intelligent employee who is jealous of his physical well-being will deliberately expose himself unnecessarily to danger. On the other hand, employers will scarcely admit the propriety of countenancing practices that so clearly decrease both economy and safety. If, therefore, because of errors of judgment, faulty instruction, and poor discipline slips and falls and other accidents occur that result in injuries, it may reasonably be concluded that there should be a firm determination to proceed with a worth-while work on a newer and more effective basis. By concentrating upon the prevention of accidents rather than injuries, and by recognizing of the fact that no accident, whether or not it results in an injury, is too insignificant to receive consideration, a successful attack may be launched against a problem that has become one of the most serious that confronts the executives of industry.

Illustrations.—Here are a few of the specific cases from which the ratios previously mentioned were determined:

Case 1

An employee, in going to and from work, took a short cut that obliged him to climb a fence and cross a railroad siding that was a part of the plant premises. Cars spotted at this point frequently prevented a clear vision of the tracks, and the noise of the plant machinery (24-hour operation) made it difficult to hear warning whistles and bells. One day, at noon, this man stepped from behind a freight car directly into the path of an oncoming engine. Crossing the tracks at this point was forbidden, and notices to that effect were posted. A fence was provided. Trainmen used whistles and bells. In short, the situation was normal, except for nonenforcement of instructions. The employee admitted that he had crossed the tracks four times a day for two and one-half years—or approximately three thousand times prior to his injury—and that in many of these instances he had narrowly escaped injury.

Case 2

An employee slipped and fell on a wet floor and fractured his kneecap. For more than six years it had been the practice to wet down too great an area of floor space at one time and to delay unnecessarily the process of wiping up. Slipping on the part of one or more employees was a daily occurrence. The ratio of no-injury slips to the injury was 1,800 to 1.

Case 3

In splitting a board, a circular-saw operator suffered the loss of his thumb when, in violation of instructions, he pushed the board past the saw with his fingers, instead of using the push stick that had been provided for the purpose. He stated that he had always done such work in this manner and had never before been hurt. He had performed similar operations on an average of twenty times a day for three months and had therefore exposed his hand in this way over one thousand five hundred times.

Case 4

A millwright attempted to put a 5-inch belt on a revolving pulley 24 inches in diameter. Tight and loose pulleys were not provided, no belt pole was used, the employee wore a loose jumper with long sleeves and stood on a shaky stepladder while slipping on the belt from the under side. He was caught and killed. Investigation indicated that this method of slipping on the belt had been employed daily for several years. The ratio here is 600 to 1.

Case 5

Potential-injury accidents not only endanger an individual but also frequently lead to disasters that take the lives of many persons at once. This is illustrated by the following:

Seventeen passengers in a motorbus were killed or seriously injured when a fire occurred while the bus was being fueled. The gasoline-station attendant was an inveterate cigar smoker and invariably failed to remove the cigar from his mouth when filling gasoline tanks. The ratio in this case was several thousand to one.

Other recorded instances show that the repetition of no-injury accidents eventually leads to explosions, fires, and resultant panics, wrecks, and other catastrophes that cause tremendous loss of life.[1]

The foregoing statements and figures furnish convincing proof of the unsoundness of the theory that serious injuries, or major accidents as industry erroneously terms them, should be made the basis of accident-prevention work; on the other hand, they also show that, on the average, accidents of various kinds are of equal weight. The natural conclusion follows, moreover, that in the largest injury group—the minor injuries—lie the most valuable clues to accident causes that should be removed through effective prevention work.

In making a survey of 100 typical manufacturing plants, it was found that, in the majority of them, the causes of the serious injury accidents, over a given period, did not fairly picture the unsafe practices and conditions needing first attention. Accident-prevention work in these plants was misdirected, since it was based largely upon the investigation of major injuries, and many other serious injuries of a slightly different nature later occurred.

It would be unfair to many progressive and clear-thinking plant executives to infer that this condition is universally found. As a matter of fact, it has been partly through the cooperation of

[1] It is perhaps unnecessary to say that there are instances in which an injury occurs the very first time an error is made and that the examples selected for illustration, although of frequent occurrence, are probably also unusual. The ratio of 10 accidents to 1 injury, however, which actually results from research, is ultraconservative.

Inasmuch as these potential-injury accidents are all occurrences that may readily be observed, it is apparent that an alert supervisor—one who has the interests of both employee and employer at heart—has a splendid opportunity to check accident-producing conditions long before an injury actually happens.

certain employers who are now concentrating on minor injuries and through a study of the data furnished by them that much of the theory that forms the basis of this text has been substantiated.

Undoubtedly a healthy condition exists when attention is concentrated upon the prevention of fatalities and serious injuries. This work should not be neglected, but the general problem will be more speedily solved if the causes of the accidents that produce all injuries, regardless of severity, are first selected as a basis for work, and then with a clearer knowledge of the frequency and the significance of no-injury or potential-injury cases, accident prevention is more intimately merged with routine industrial work.

SECTION 5.—REASONS FOR THE UNSAFE HABITS OF MEN

If a safety engineer were obliged to choose between "safe, capable, and experienced men who work under unsafe conditions" and "unsafe, incapable, and inexperienced men who work under safe conditions" he would probably choose the safe-man combination as the one most likely to produce a clear accident record.

The guarding of machines and mechanical hazards has been and always will be a fundamental of a complete safety program. Guarding and other action of an "engineering revision" nature often provide a remedy even for accidents caused chiefly by man failure. This being so, it is unwise to depend automatically and invariably on educational or supervisory methods when the accident problem centers about unsafe personal practice.

By far the most sensible thing to do is to find the *reasons why* unsafe acts are committed and then to devise practical action for correction, be it in the engineering revision or educational field.

It will be generally agreed that present-day methods of prevention for unsafe performance fall into the following groups of activities:

Instruction.
Enforcement of instruction.
Education and discipline.

There will be general agreement also that the particular method selected depends largely on the personal preference of some one authority, on what has been done by others, on what seems easiest, and on many other things, but *not* on adequate knowledge of the reasons why persons, in special cases, violate safe-practice rules.

To a certain extent, of course, consideration has always been given to the need for finding *why* persons do unsafe things. But such consideration too often has been intermittent and casual—seldom has it been conscious and continuous. This line of investigation has not been planned and carried on as a separate step—rather, when done at all, it has been instinctive and incidental, although actually it is a most important single factor in accident analysis and in the building of helpful remedies.

There have been cases where his football career has interfered with an architect's education. The architect then made a mistake, the engineer failed to check, the structure was faulty, a slight overload resulted in collapse, and a poorly supervised workman exposed himself unnecessarily and was killed. These circumstances are all related and are part of the cause-and-effect chain, like the story of "The House That Jack Built."

The reader is asked at this point, however, to keep in mind that this discussion is concerned primarily with the "first, direct, and proximate reasons why persons commit unsafe acts" and does not refer to the gamut of so-called "basic" causes of accidents.

A few illustrations may serve to prove that there is a need for finding the reasons for unsafe acts and that when these are discovered they lead to the proper selection and application of effective measures in accident prevention.

Example 1.—An accurate and thorough analysis had been made of public and property damage accidents in which a commercial fleet of automotive vehicles had been involved over a period of years. Mechanical equipment was found to be safe. The drivers were at fault. Specifically, they followed too closely for the speed at which they were driving. Question—what was the remedy?

Previously, in this case, remedial action, which had been selected at random, consisted merely in issuing instructions (and attempting to enforce them) to the drivers to follow cars at a safe distance. This had not served to reduce the accident frequency, however. There were several groups of drivers and several departments of work. Finally, the decision was reached to find out the "why" or the reason for the violations, preparatory to planning a better remedy. The results were startling.

In one group of drivers it was found that the few who were responsible for the poor record were *inherently reckless.* The remedy became a simple matter of managerial personnel procedure.

The drivers in group two were not reckless at all, but they were *wholly unconvinced that it was unsafe to follow closely.* The remedy, obviously, was a special form of education.

In a third group there were many drivers with *defective eyesight* who were unable to judge distances accurately. The remedy was found to lie in ocular examination and the provision of glasses with prescription lenses.

Group four drivers found it *impossible to follow at a safe distance* because of time-schedule requirements. In heavy city traffic the creation of a gap of much more than a car length or two provided a temptation for another driver to pass and pull in ahead. This necessitated dropping back again, thus creating another gap. In short, any attempt to live up to the rule for following safely destroyed all chance of meeting the time schedule. The remedy lay in rerouting and in revision of schedules.

The remedial actions indicated by the reasons enumerated in this example were made effective, and, as may readily be anticipated, the accident frequency dropped immediately and substantially.

It is of interest to note that four distinctly different methods of correction were used, each one fitted to the circumstances in a particular department.

Example 1 was taken from the automotive work of an industrial concern, but this discussion relates to all industrial activities. An example that applies to the chemical industry follows.

Example 2.—In this case employees violated the company safe-practice rule relating to washing before eating luncheon. All efforts in the way of instruction, supervision, and education had failed to produce results. The reason for the unsafe act was finally found, and it developed that the washrooms were uncomfortably drafty and that the water was cold and hard. In short, the unsafe act was committed largely because it was *inconvenient* and *uncomfortable* to follow safe practice. When ventilation was improved, more suitable free-lathering soap provided, and warm water made available, the men readily made proper use of washroom facilities. This is one of the many instances where engineering revision is found to be an answer to man-failure accident-and-health problems. The moral, moreover, is that success came about only when cause-analysis was carried to the point where the reason for the unsafe act was ascertained.

Example 3.—In this instance, extreme difficulty was encountered in getting shipping-department employees to stop the practice of jumping off loading platforms. Here it was found that the men were by no means convinced that jumping approximately three feet was at all unsafe. They were not reckless, it was quite convenient to use the stairs at either end of the platform, and no other probable reason, except the one selected, was applicable. A table in Chap. IV shows that education is the remedy when men act unsafely because they are not convinced that their actions are unsafe. The safety engineer, being now adequately informed, proceeded to develop an effective educational campaign designed to remove all possible doubt as to the hazards of jumping. He obtained the services of a surgeon-physician who gave talks illustrated by charts. The charts showed the bone and muscular structure of man as compared to that of four-footed jumping animals such as the dog and the antelope. It was conclusively demonstrated that man is poorly equipped, indeed, when it comes to jumping, by comparison with such animals. A dog lands on well-padded toes, and the shock is absorbed by several more joints and by less rigid anatomical structure than is the case with a man. It was pointed out, further, that the abdominal support of man was designed for horizontal (four-footed) carriage, and that in walking erect the original support was necessarily ineffective and was replaced by a thin membrane. The first lecture was so impressive that an employee who was the chief offender was observed to tighten his belt as he left the room and to "hold himself in" as he stepped carefully over the threshold of the doorway, saying at the same time, "I'm sold."

Suffering heavily by contrast with these examples is the slipshod, hit-or-miss guesswork which presupposes that a single form of prevention work—education or guarding, for example—will suit any and all occasions.

Surely, it would be a waste of time to preach the doctrine of safety to a group of drivers who already believed in it and who drove unsafely only because they could not see well enough to judge distance properly. Especially would it be wasteful if the defects in vision *were not known* and consequently if *nothing were done about it.* How much simpler and more direct and effective is the procedure finally adopted in Example 1, namely, *finding the reason for* the unsafe act and *basing the remedy on that reason.*

Surely, too, it would be useless to fit glasses to drivers, such as those in group four of Example 1, or to educate or discipline them. Those drivers were physically sound, they were fully aware of the danger in following the car ahead too closely, and they were not at all reckless—they were forced to drive unsafely by improper routing and timing.

The method whereby unsafe acts are to be corrected must suit the *reasons* for the occurrence of the unsafe acts.

How many kinds of these reasons and remedies are there? Is the question involved and complicated? Does it enter the field of psychology or psychiatry? Is it one that the average safety engineer can solve? Fortunately, from the viewpoint of progress, the answers to these questions are all cheerfully simple and encouraging. Indeed, psychology of a sort is involved, but it need only be of an elemental and understandable nature which the average safety engineer or industrial supervisor can readily apply. The matter therefore is not impractical or too complicated. In fact the reasons for the commission of unsafe acts are so few that it has been found practicable to list them in Chap. IV.

Briefly these reasons or causes for the unsafe acts of persons may be placed under four general heads, namely:

1. Improper attitude.
2. Lack of knowledge or skill.
3. Bodily defects.
4. Safe practice difficult or impossible.

Note 1.—These items apply only to the persons who commit the unsafe acts. They can be said to be the first, proximate, or direct reasons. Other reasons are underlying. For example—an employee who *fails to wear goggles* (the unsafe act) *may not be convinced that such action is really unsafe* (the proximate or direct reason for the unsafe act) *because he was inadequately supervised* (the underlying or subreason). It is axiomatic, however, that error is invited if we act on underlying data without first having determined and made use of the more direct facts.

Note 2.—From the above it is clear that remedial action in accident prevention may be grouped roughly in six classifications:

1. Education.	Instruction in safe practice, providing proof and illustration, inspiring enthusiasm, convincing, etc.
2. Engineering revision.	Guarding, redesign, relocation, etc.
3. Placing.	Assignment of workers to relatively less hazardous work.
4. Discipline.	Enforcement of rules, militaristic methods, penalties, etc.
5. Medical treatment.	Treatment of bodily defects.
6. Psychology.	Treatment of attitudes, etc.

In the field of industrial-accident prevention, as in other fields, there is progress and a constantly broadening vision. Out of the haze and ambiguity of past years, definite factors begin to take shape. It is now known that falls of persons and other types of accidents can occur only as the result of unsafe acts or because of mechanical or physical hazards. Little difficulty is experienced in correcting the mechanical hazards, but the correction of unsafe acts will remain troublesome unless there is a better understanding of the reasons or motives that permit these unsafe acts to occur.

The purpose of this discussion is to point out that definite causative factors lie directly behind the occurrence of unsafe acts, that they are few in number, practicable of identification, and extremely valuable as direct clues to the selection of corrective action.

SECTION 6.—ANALOGY BETWEEN METHODS OF CONTROLLING ACCIDENT HAZARDS AND PRODUCTION FAULTS

The control of quality and quantity of product and of the frequency and severity of accident occurrence have much in common. In many cases the same faulty practice is involved, and the reason for existence of the fault is similar, both for accident occurrence and for unsatisfactory production.

If it is known as a result of a correct fact-finding job that a particular unsafe practice is chiefly responsible for accident occurrence, it can safely be assumed that the methods best suited to correct that particular practice are identical with managerial and supervisory methods such as would be used if the practice were not unsafe but were one that resulted in impaired or high-cost production. Suppose, for example, that in stevedoring work analysis discloses that men are being injured because they "work under open hatches when drafts are being hoisted." If it is also known that this practice is being carried on in willful disregard of instruction, an executive with ordinary supervisory ability should be able to select and apply a remedy successfully. To make the point clear it is necessary only to visualize what such an executive would do if, instead of violating that safe-practice rule, the same employees willfully disregarded rules concerning the overloading of drafts with the result that materials spilled out and were smashed, creating a property-damage loss which the employer must pay.

The employees are paid to perform their work in a prescribed way—that is, to stand clear of the hatches while material is being hoisted. The foremen are paid to see that employees carry on their work as instructed. The employer has a right to expect of wage-earning employees that they obey common-sense rules. He wants the men to stand clear, and he wants the foremen to see that they do so. Both groups of wage earners fail to do as he asks. What further is there to say, except that *the responsibility lies first of all with the employer?* If he has an earnest desire to reduce the frequency and cost of accidents, if he recognizes his responsibility for the safety of his workers, and if he is aware of the fact that methods of achieving safety are analogous with methods of controlling production, he will exercise his prerogative and obtain compliance with instructions. Moreover, he will follow through and see that the unsafe conditions are eliminated, just as he would do if insubordination or carelessness of employees resulted not in accidents but in delays, spoilage, breakage, defective merchandise, or low production.

In a drop-forge plant an inspector was definitely instructed to gauge roughed-out forgings in three dimensions. He disregarded the instruction, however, and gauged them for length and width only. As a result, a large order was canceled when the purchaser found that several forgings of the first batch received from the shop were of less than the specified thickness.

This situation is typically analogous to many accident-prevention problems, and its manner of correction is identical with that herein advocated for accident occurrence, as the following comparison shows:

EXAMPLE DEFECTIVE-PRODUCT PROBLEM	EXAMPLE 2 ACCIDENT-CONTROL PROBLEM
1. Improper practice—gauging forgings for length and width, but not for thickness.	1. Unsafe practice—throwing hot billets across aisle space between furnace and base of drop press.
2. Cause or reason for existence—disregard of instruction.	2. Cause or reason for existence—disregard of instruction.
3. Remedy—supervisory enforcement of instruction to gauge for three dimensions.	3. Remedy—supervisory enforcement of instruction to carry billets to drop press with tongs.

The executives in charge of the drop-forge plant referred to in both examples experienced no difficulty whatever in applying the remedy for defective product in Example 1. They would hardly have been satisfied to deal with such elemental and definitely known faults by means of general education through bulletins, meetings, and talks, or by other indirect methods. They lost no time in identifying the improper practice and in correcting it by eliminating the reason for its existence through appropriate supervisory procedure.

For two years, however, they struggled with the accident problem (Example 2), notwithstanding the fact that it could have been disposed of in a very short time by employing methods similar to those used in the first case.

SECTION 7.—RESPONSIBILITY FOR ACCIDENT OCCURRENCE AND ACCIDENT PREVENTION

Existing laws, rules, and ordinances require in varying degree that workplaces, machinery, and equipment be maintained in safe condition, that adequate first-aid facilities be provided, that accidents be reported, and that the employee be compensated when accidentally injured. The burden of responsibility for compliance with these requirements is fixed and defined by law. The moral obligation of an employer to his employee and to society requires that a reasonably safe working environment be maintained. It likewise demands that consideration be given to the physical and mental fitness of employees to perform safely the tasks to which they are assigned, that adequate training and instruction of employees in safe methods be provided, and that a systematic effort, suited to the individual circumstances and conditions, be made to eliminate, minimize, and control the physical and mechanical hazards and the unsafe actions of persons who have produced accidents or are likely to do so.

Dependence must be placed largely on the recognition by management of its moral rather than its legal responsibility for preventing accidents, not only because existing legal requirements are limited in scope, but also because it is a most difficult task to be practical and fair in any attempt by law to achieve wholly safe employee working conditions. This is due in part to the fact that the worker himself is often negligent and in part to the complexity and tremendous variation of industrial processes.

As herein used, the term "management" applies broadly to the entire managerial and supervisory staff of an industrial organization. In the case of a "one-man" company, where the establishment is so small that the owner is also the superintendent and the foreman, managerial responsibility clearly rests on this one man. Where the organization consists of several executives, they must all share the obligations of management.

The line of demarcation, therefore, between management and employee lies in the authority to issue orders or to direct work. A foreman, a leader, or even a "straw boss" is a representative of management, and because he is authorized to direct the work of employees, he is a part of management.

The moral responsibility of management for industrial accidents is well expressed by Dr. L. P. Alford from whose paper, presented before the Annual Meeting of the A.S.M.E. Safety Committee in New York City in December, 1930, the following excerpts are quoted:

> An industrial accident . . . must be considered as evidence of some fault of control of the operating conditions and forces. The exception to this statement is found in those few cases where random causes, which cannot be predicted and controlled, produce the accidental

happening. Where control is perfected, accidents are brought down to the irreducible minimum, which in numerous cases has been zero for considerable periods of time so far as lost-time accidents are concerned.

Responsibility for a "fault of control of the operating conditions and forces" in an industrial establishment can be assessed only against the center of management. This center is that individual, or small group of individuals, who exert the directing will in that concern. In this center is the managerial skill which makes for success; while its lack leads on to failure.

Upon this center of management rests the responsibility for initiating a program for accident prevention, and for the continuing care to make such a program effective.

The immediate and proximate causes of industrial accidents such as "falls of persons" are known to lie in two general groups, namely, mechanical or physical and personal. Both causes are controllable by management, and in the case of both, management has an unexcelled opportunity to exercise remedial action. Management further has a strong incentive to prevent accidents, because accident occurrence has a direct and seriously detrimental effect on quality and volume of product, cost of production, and on profit and efficiency in general.

In addition, and of even greater significance, the individuals who comprise "management" are deeply concerned with regard to the necessity for safeguarding the lives and limbs and welfare of employees.

Management Controls Mechanical or Physical Accident Causes.—Mechanical or physical causes of accidents include such typical hazards as unguarded or inadequately guarded machines, tools, and equipment, machines and tools or other devices that are worn, frayed, broken, of insufficient strength, or otherwise defective, and inadequate light or ventilation in workplaces.

These conditions are obviously within the control of management. To begin with, management selects, purchases, installs, and makes use of the equipment. It may in certain cases actually design and build the equipment. Management is the owner of such equipment and may be said to be the sole authority in final decisions as to its handling, operation, maintenance, placing, and guarding. Management pays the bills when, as a result of accident, equipment is damaged or destroyed or when accidents interfere with the continuity of production. The persons who are charged with the task of building safety into mechanical equipment, planning safe and efficient manufacturing processes and procedures, repairing and replacing defective equipment, and otherwise making and maintaining safe working conditions are directed by management. Where control is so placed and opportunity so great, it cannot fail to be evident that moral responsibility also exists. In every sense of the word, therefore, management is logically and properly responsible for safe mechanical and physical conditions in the workplaces of which it has charge.

Management Controls Personal Causes of Accidents.—Personal causes of accidents are unsafe acts of persons as:

Oiling machinery while it is in motion.
Removing guards from machines.
Riding suspended loads.
Throwing material in work spaces.

Management's responsibility for controlling the unsafe acts of employees exists chiefly because these unsafe acts occur in the course of employment that management creates and then directs. Management selects the persons upon whom it depends to carry on industrial work. It may, if it so elects, choose persons who are experienced, capable of and willing to do this work, not only well but also safely. Management may also train and instruct its employees, acquaint them with safe methods, and provide competent supervision. In following the principles of delegated authority, management, through its representatives in the supervisory staff, may set a safe example, establish standards for safe performance, and issue and enforce safe-practice rules.

It is tacitly understood, by a person who accepts wages in return for his services, that his employer has a logical right to ask that he do the work for which he is remunerated in the way his employer wants it done, provided always that the request is reasonable. Surely it is reasonable to expect that safe-practice rules will be obeyed. The employer, therefore, has an opportunity that he is morally obligated to fulfill, to obtain compliance with safe-practice rules just as he obtains compliance with rules and instructions relating to the quality or tolerances of manufactured product. In the case of unsafe personal performance, therefore, no other proper conclusion can be reached than that because of its ability and its opportunity, management is responsible for accident prevention.

Cost of Accidents an Incentive for Management.—In the cost of industrial accidents there lies another incentive for management to prevent accidents—one that indicates moral responsibility for taking action. The responsibility rests in this case not directly with the employee or society so much as with the industrial establishment, its stockholders, directors, or company members whose time and capital are invested and at stake.

The direct cost of accidents, as represented by compensation payments, first aid, medical and surgical expense, plus legal fees and overhead, may be approximately portrayed by compensation insurance rates or premiums. In the high-hazard industrial classifications these compensation insurance rates may be as much as 20 to 30 per cent or more of the total payroll. Direct accident cost in itself is thus shown to be a material factor in efficient management, but it is nevertheless tremendously overshadowed by the vastly greater cost referred to herein as "hidden" or "incidental."

Safety and Production.—It has long been held that a definite relation exists between efficiency in production and safety, but proof of the belief was not available until the publication in 1928 of the results of research made by the American Engineering Council.

The excerpts taken from the publication referred to and quoted in Section 8 of this chapter entitled "Safety and Production," indicate that management is provided with an incentive that carries with it a definite responsibility for accident prevention.

Responsibility of Safety Engineer.—The safety engineer referred to in this discussion is the industrial safety engineer who is employed by management. He is representative of and a part of the managerial and supervisory staff that directs the work of employees, and he therefore shares the responsibility of management for accident prevention as already described.

Being specially qualified in safety work and often in direct charge of it, the safety engineer has the opportunity to impart his knowledge to others. He may make periodic inspections or surveys of the plant and industrial operations, the machines, appliances, equipment, tools, procedures, and processes for the purpose of determining mechanical or physical hazards and unsafe practices of employees. He makes recommendations and suggestions for improvement, takes part in the training and education of supervisors and employees, conducts or participates in safety meetings, acts as a coordinator of safety work and as a liaison agent with higher executives. In general, he supervises and promotes the work of accident prevention as a specialized individual task.

Responsibility of the Foreman.—The statements heretofore made with regard to the responsibility of management are applicable to the foreman also.

In other than so-called "one-man" organizations, the principle of delegated authority must obviously be followed, and this places responsibility on the foreman as management's representative to issue and enforce orders.

The foreman, moreover, is in a peculiarly strategic and tremendously important position so far as attaining results in accident prevention is concerned. He is the man who actually gives orders and instructions to the employees. He explains, instructs, interprets, and enforces the orders. From the employees' point of view the foreman's word is authoritative and final.

The foreman is closely associated with his men and may work side by side with them. He is often as skilled or more so than the employees. He knows his men personally and has a splendid opportunity to become acquainted with their habits, grievances, attitudes, and personal as well as business qualities. His influence and example, as well as his authority, provide him with a degree of control over his men that is of the greatest importance in safety work. Undoubtedly the foreman is the "key man" of industry.

No safety program, in view of the foregoing circumstances, can hope to be wholly successful without the sympathetic and intelligent support of able foremen.

Responsibility of Employee and Nonemployee.—The responsibility of the employee for accident prevention is primarily a selfish one. He is of course responsible for his own safety, and he is also under an obligation to his dependents and to society for keeping himself physically sound enough to maintain his efficiency as a wage earner.

However, the individual employee who is without supervisory authority does not issue or enforce orders; he lacks opportunity to instruct fellow employees and therefore cannot well be held responsible for the mechanical or physical hazards of the establishment in general.

In the sphere of his own specific duties the employee has certain responsibilities to his employer for the safe conduct of his work and the maintenance of equipment. He should report unsafe conditions to his supervisor when these are not within his authority to control. He should see that other employees do not interfere with his work in such a way as to create accident possibilities. He may have opportunities to impart his knowledge and experience in safety matters to his fellow employees and may take an active and helpful part in safety meetings.

In general, it would seem that although the opportunities and responsibilities of the individual employees are limited, they are nevertheless of great cumulative importance.

The nonemployee, with rare exceptions, has no part in managerial responsibility, nor has he any obligations for the safety of any part of the industrial work of a given establishment.

His responsibility is chiefly that of avoiding interference with persons or procedures in such a way as to create unsafe conditions. Nonemployee safety engineers and other persons who are invited by management to take part in industrial safety work and specialists and experts who are authorized to cooperate with the managerial or supervisory personnel are not included in the foregoing reference to nonemployee responsibility.

Degree and Classification of Responsibility.—The legal responsibility of management is fixed and defined by law. Moral responsibility cannot well be classified nor can its extent or degree be definitely established as it applies to individuals or groups included in "management."

An illustration may serve to make this point clear.

An employee, while filling a drum with a highly corrosive acid from the swinging spout of an overhead gravity tank, allowed his attention to wander. The drum overflowed and the employee was seriously burned.

Gloves, apron, goggles, and mask had been provided, and instructions to wear them had repeatedly been given. They were not worn. The operation was one that was commonly conducted in other plants. No previous trouble had been experienced.

The employee undoubtedly was negligent, first in paying insufficient attention to his work, and second, in failing to wear the equipment that had been provided.

Supervision, however, was also at fault. It was inadequate and most certainly ineffective in that it had not impressed the injured man sufficiently with the hazards and with the need for care, nor in this case did it observe and correct the unsafe practice that had been carried on for some time before the accident.

Higher executives were likewise responsible in several ways. The process could have been, and in fact was after the accident, more safely designed, employee and supervisor selection and training could have been better, and there was lack of system and foresight in the failure of management to keep closely informed concerning the probable hazards of its manufacturing processes.

Accident prevention is a cooperative task of vital importance in our social and economic life, in which management assumes the major responsibility, the employee must do his share, and the foreman bears most of the burden of detail.

SECTION 8.—INCIDENTAL COSTS OF ACCIDENTS

Compensation laws place the burden of industrial-accident responsibility upon the employer of labor, and educational methods reach the employee mainly (and often only) through the employer. The guarding of machinery must be accomplished by the employer or with his full cooperation. The elimination of unsafe methods and processes is under the control of the employer. And in fact the entire structure of the accident-prevention program rests upon employer-executive participation and action. It is fortunate for the cause of safety, therefore, that action on the part of these employer executives is defensible from a purely business viewpoint as well as from that of humanity.

Annual Industrial Accident Record.—The annual industrial accident toll in the United States is now estimated at 17,000 deaths and over 1,400,000 lost-time injuries. Probably more than 40,000,000 additional minor injuries also occur annually. The prevention of injuries to employees is clearly a highly commendable humanitarian work and will continue to progress on its own merits. In addition, it has been established that accident prevention is *good business* and that it is entirely defensible even from a purely mercenary viewpoint. The truth of this assertion is quite generally acknowledged today and is constantly gaining wider acceptance as the result of the adoption and successful application of sound accident-prevention methods.

Hidden Accident Costs.—To industrial executives is offered the incidental or, more correctly, the hidden or indirect, but nonetheless real, employer cost of accidents, an indisputable evidence of the need for recognizing accident prevention as an important essential in sound business management.

The many and varying estimates of the annual cost of industrial accidents are stated in terms of millions of dollars and are usually based upon the lost time of the injured worker. This is largely an employer loss, inasmuch as the employee is partially compensated; but it is far from being all of the cost to the employer. The remaining additional, and so-called "incidental," cost has been found by research to be *four times as great as* compensation and medical payments. Expressed in another way, compensation payments constitute only one-fifth of the total employer accident cost. The accuracy of this estimate has been demonstrated by application to scores of specific plants. The Associated General Contractors of America state that the cost is probably higher in construction work.[1]

It is not contended that the four-to-one proportion holds true for *every* industrial accident or *every* individual plant, and it is granted that in nation-wide application the ratio may vary; yet it has already been tested sufficiently to provide approximate confirmation.

[1] Associated General Contractors of America, "Manual of Accident Prevention," 1928.

This four-to-one ratio should prove to be a powerful stimulus to preventive action. It may come as a distinct shock, pleasant or otherwise:

To statisticians, who will find by its use that cost generalities in million-dollar terms are trebled or quadrupled.

To employers who complacently accept average losses as incidental to their operations.

To employers who do not worry about accident cost because they believe themselves to be fully compensated by insurance.

To employers who feel that overhead cost is only slightly affected by accidents.

To employers who consider accident prevention as something for the other fellow to do.

To employers who are apathetic toward accident prevention or who are mildly interested only for humanitarian reasons.

To employers who feel that they cannot afford to establish safety on an organized basis.

To safety engineers who wish to prove that their work has a real monetary value.

To insurance salesmen, who will find that it enhances the value of the service that they sell.

Factors in the Hidden Cost, to Employers, of Accidents to Employees.—The calculations from which this four-to-one ratio was derived were based on the factors that follow. Compensation and liability claims, medical and hospital cost, insurance premiums, and cost of lost time except when actually paid by the employer without reimbursement are excluded:

1. Cost of lost time of injured employee.
2. Cost of time lost by other employees who stop work:
   a. Out of curiosity.
   b. Out of sympathy.
   c. To assist injured employee.
   d. For other reasons.
3. Cost of time lost by foremen, supervisors, or other executives as follows:
   a. Assisting injured employee.

  b. Investigating the cause of the accident.
  c. Arranging for the injured employee's production to be continued by some other employee.
  d. Selecting, training, or breaking in a new employee to replace the injured employee.
  e. Preparing state accident reports, or attending hearings before state officials.

4. Cost of time spent on the case by first-aid attendant and hospital department staff, when not paid for by the insurance carrier.
5. Cost due to injury to the machine, tools, or other property or to the spoilage of material.
6. Incidental cost due to interference with production, failure to fill orders on time, loss of bonuses, payment of forfeits, and other similar causes.
7. Cost to employer under employee welfare and benefit systems.
8. Cost to employer in continuing the wages of the injured employee in full, after his return—even though the services of the employee (who is not yet fully recovered) may for a time be worth only about half of their normal value.
9. Cost due to the loss of profit on the injured employee's productivity, and on idle machines.
10. Cost of subsequent injuries that occur in consequence of the excitement or weakened morale due to the original accident.
11. Overhead cost per injured employee—the expense of light, heat, rent, and other such items, which continues while the injured employee is a nonproducer.

This list does not include all the points that might well receive consideration, although it clearly outlines the vicious and seemingly endless cycle of events that follow in the train of accidents. The application of this set of factors is illustrated by the following typical examples, taken from actual experience:

Case 1

Total cost of compensation and medical aid	$209
Total additional incidental cost, paid directly by the employer	937

The following accidents occurred on a building erection job:

Number of Accidents	Description of Accidents		Compensation and Medical Cost
3	Fractures and contusions	Material hoist	$106
18	Rivet burns, cuts, bruises	Miscellaneous operations	76
21	Falling materials	Miscellaneous operations	15
30	Slips and falls	Miscellaneous operations	12

The incidental cost was computed as follows:

Time lost by injured employees, paid directly by the employer	$116
Time lost by other employees	310
Time lost by foremen and superintendent	78
Property damage	158
Payment of forfeits (two days) for failure to complete the job on time	200
Portion of overhead-cost loss during delay	75

An interesting point developed by this analysis is the relatively high cost to the employer, on account of the time lost by employees other than those who were injured. This was due chiefly to one of the material-hoist accidents. Shaftway inclosures were not maintained as good practice demands, and one employee, who was working in the vicinity of the hoist, was injured when he carelessly allowed a heavy plank to project into the path of the ascending car. The hoisting cables were torn from their fastenings, causing the car to drop. Labor on the upper tiers was necessarily suspended pending the completion of repairs.

Another feature worthy of note is the loss due to forfeits. The contractor himself estimated that delays caused by the accidents interfered with the completion of the job at the time agreed upon, thereby penalizing him to the extent of $200.

Case 2

Total cost of compensation and medical aid	$ 66
Total additional incidental cost, paid directly by the employer	275

This example was obtained from the records of a hardware manufacturing plant and covers an experience of six months.

The following accidents occurred:

Number of Accidents	Description of Accidents		Compensation and Medical Cost
1	Lost nail of index finger	Punch press	$61.50
1	Lacerated forearm	Baling press	4.50
9	Cuts on hands	Handling sheared metal	0.00
10	Slips and falls, dropping objects	Miscellaneous operations	0.00

The incidental cost was computed as follows:

Value of labor and material in connection with canceled order	$107
Time lost by injured employees (paid by employer)	36
Time lost by other employees	34
Cost of repairs to stamping dies	33
Unearned wages (the employer paid a slightly injured skilled employee ten days' full wages—$6.30 a day—receiving in return unskilled labor worth $2.50 a day)	38
Time lost by foreman and superintendent	27

The visible direct cost in this example lies in the relatively infrequent serious accidents, whereas close analysis shows that a large part of the incidental cost is due to the trivial injuries.

One of the injuries described on the employer's records as "slips and falls—dropping objects" occurred to a toolmaker who, on account of laxity in supervision, was indulging in a bit of gossip while operating an engine lathe. His attention being temporarily diverted from his work, he allowed the lathe tool to feed into a shoulder of a jig that was mounted on the face plate of the lathe, tearing the work loose from the face-plate clamps and causing it to drop upon his fingers and jam them against the lathe bed. The jig (original value $48) was ruined. The cost of the jig, however, is not included, since it was merely being repaired for stock, and its actual value at the time of the accident was difficult to ascertain. What is of more interest, however, is the fact that, because of his bruised and bandaged fingers, this skilled toolmaker was unable to undertake the building of a set of blanking dies that were ordered the same day that the accident occurred. Another toolmaker was employed for that purpose, and the injured man was transferred to work requiring less skill. Thus, for a time, the employer paid the wages of two skilled men and received in return little more than the labor of one.

The punch-press injury is also of interest from the point of view of incidental cost. Orders had been issued to the effect that the pressroom foreman must be called in case stock became jammed in the dies. These orders were not rigidly enforced, and one of the press operators, observing that a blank had been pulled up by the punch so that it obstructed further feeding, tried to remove it with a metal rod and accidentally stepped on the clutch pedal at the same time. The dies were thrown out of alignment and seriously sheared, and at the same time the employee's finger was nipped under the spring stripper plate. The delay incidental to repairs in this case was sufficient to cause cancellation of the order on which the operator was working, thus creating a labor and material loss of $107, according to the manufacturer's statement.

Case 3

Total cost of compensation and medical aid	$ 0
Total additional incidental cost, paid directly by the employer	154

The incidental cost was computed as follows:

Cost of wasted materials	$93
Cost of time lost by injured employees	37
Cost of time lost by employees other than those injured	24

For a period of 60 days, following the inauguration of a no-accident campaign in this plant, there was not a single compensable injury or one that required professional medical treatment. There were 66 minor accidents, however—chiefly burns due to the unsafe acts of employees when handling caustic or corrosive materials.

One of the men who was not seriously injured but who was nevertheless in no condition to carry on his work was a skilled chemist upon whom the concern was depending to provide an analysis prior to the fulfillment of a large rush order. In his absence the work was done by a less skilled employee, who bungled the job. The work of filling the order was begun before the error in the analysis was discovered, resulting in waste of materials and dissatisfaction on the part of the customer on account of delay in the delivery of goods.

Case 4

Total cost of compensation and medical aid	$ 59
Total additional incidental cost, paid directly by the employer	262

Here is the cost record of 36 injuries in an average woodworking plant manufacturing interior trim and doing some cabinetwork:

The following accidents occurred:

Number of Accidents	Description of Accidents		Compensation and Medical Cost
1	Hand severely cut	Jointer	$51
15	Cuts and bruises	Handling material	5
10	Slips and falls, falling objects	Miscellaneous operations	3
1	Finger slightly lacerated	Band saw	0
1	Bruised forehead	Struck against machine	0
8	Miscellaneous cuts and bruises	Hand tools	0

The incidental cost was computed as follows:

Time lost by injured employees (paid by the employer)	$ 48.00
Cost of time lost by other employees	116.00
Time lost by foremen and superintendents	79.00
Spoilage of material	11.40
Broken and damaged tools	7.60

Here, again, a significant feature is that the incidental cost of the time lost by employees other than those who were injured was greater than the incidental cost of the time lost by the injured employees themselves. A part of this time was lost because fellow workers crowded about in sympathy or curiosity or to give assistance to the injured employees. The major time loss, however, was due to the fact that a certain foreman was not readily available for consultation for a period of one week, because during that time he was obliged to operate a production machine. This situation was brought about by a preventable accident on a partially guarded jointer that was being used temporarily as a molder. It was essential that production be continued, and the foreman happened to be the only remaining available skilled operator. While he was engaged in running the jointer, considerable delay and confusion existed in his department because employees who looked to him for instruction and advice were obliged to wait. Loss of production is not included in the estimate of incidental cost, but the lost time of uninjured employees in itself constitutes an item worthy of consideration.

Case 5

Total cost of compensation and medical aid	$11
Total additional incidental cost, paid directly by the employer	49

An employee in a machine shop was injured while reaming a casting on an engine lathe. He attempted to grasp the dog, which had started to revolve when the reamer pulled away from the tail-stock center. Three fingers were lacerated.

The incidental cost was computed as follows:

Injured employee, upon returning to work with his hand bandaged, was engaged for two weeks at work ordinarily performed by unskilled employees at a low wage rate. The employer, while paying full wages for two weeks, received but 50 per cent value	$33
Time spent by foreman and assistant superintendent in investigating damage to the tools and to the casting and in planning the replacement of the ruined casting	8
Lost time of several employees who left their work to assist or sympathize with the injured man and to discuss the accident	6
Cost of new reamer, to replace the one broken in the accident	2

The cost of a new casting (estimated at $50) is not included in this example, nor is the lost time (four days) of the injured employee, because there may have been some salvage on the casting, and the employee received no wages while away from the shop.

The specific point of value in this example lies in the first item of incidental cost—the wages of the convalescent employee, which continued at 100 per cent, while his services, being rendered on unimportant work, were reduced to 50 per cent in value.

Case 6

Total cost of compensation and medical aid	$ 25
Total additional incidental cost, paid directly by the employer	140

A series of 17 accidents, of which six happened on outside work, occurred to drivers and helpers employed by a trucking concern.

These accidents resulted in the usual cuts and bruises so commonly experienced by truckmen.

The incidental cost was computed as follows:

Cost of time lost by employees other than those injured..	$40
Cost of time lost by injured employee (paid by employer)	36
Cost of loss of use of trucks and horses while delayed by accidents..................................	32
Cost of damage to trucks, tackle, and other property of employer..................................	26
Fine for disobeying city parking laws..................	6

The men employed by this concern worked in crews of three or four and often moved heavy machinery or other objects requiring the concerted efforts of an entire gang. With one man being treated at a physician's office, the remaining man or men often could do nothing but wait.

One of the 17 accidents is typical. A crew of three men was moving a piece of heavy machinery when one of the men lost his grip on a crowbar and let the machine fall. His hand was hurt, and the flooring and the side of the truck were damaged. The employee was sent home by a physician, and the two remaining men, being unable to handle the machine alone and receiving no assistance from headquarters, were obliged to drive away and come back the next morning. This example shows quite clearly that the time lost by employees other than the injured may be an important item in the incidental cost of an accident.

Case 7

Total cost of compensation and medical aid........	$ 86.50
Total additional incidental cost, paid directly by the employer..................................	379.50

This is the story of six months' experience in a typical woodworking and pattern shop. The accidents were as follows:

Number of Accidents	Description of Accidents		Compensation and Medical Cost
1	Badly cut finger	Circular saw	$80.00
1	Laceration palm of hand	Chisel	6.50
12	Miscellaneous cuts	Hand tools	0.00
24	Slivers in hands	Handling material	0.00

In this example, as is the case in the average plant, the visible first cost lies in the more serious but relatively infrequent accidents, whereas a great part of the incidental cost to the employer is due to the trivial cuts and bruises. One of the 24 cases of sliver injuries is of special interest. The employee was feeding a splitting saw when the board kicked back through his hands, causing the accident. The board was thrown with sufficient force to cause serious damage to an expensive pattern of intricate design, with resultant property loss of $86.

In the case of one of the 12 miscellaneous cuts, an operator of a small vertical boring machine was using a bit from the end of which the conical thread had not been removed. The work "rode the bit," carrying the employee's hand against the chuck, causing a slight injury to his hand, and incidentally spoiling the work. This work was the last section of an otherwise completed rush job, for which the purchaser was waiting. The order was canceled and the entire value of the work was lost.

The employee who was rather badly hurt on the circular saw was a skilled man and had to be replaced at once. When he came back to work after a week's absence, he created an additional and an unbalanced item of expense in overhead cost, because for a time his employer paid the salary of two skilled operators for work that either one could normally do alone.

The incidental cost is computed as follows:

Time lost by injured employees	$62.50
Time lost by other employees	50.00
Time lost by foremen and superintendent	47.00
Cost to employer in paying full wages ($40 per week) to the employee upon his return to work, when the actual value of his work was but $10 per week (see foregoing explanation)	90.00
Value of ruined pattern	86.00
Value of work and material for the order canceled	44.00

In this example, as in the others cited, only actual measurable losses are included. This employer lost the confidence of the customer, who canceled his order in pique on account of the accident and delay, and goodwill as an asset was therefore impaired. This sometimes is a significant factor, although it is impossible to value it accurately.

Case 8

Total cost of compensation and medical aid	$ 50
Total additional incidental cost, paid directly by the employer	230

This case comprises a group of 100 typical injuries in a clothing-manufacturing plant and includes the usual cuts, bruises, and infections. Ten of the injured employees were treated by physicians, and the others required first aid only. This employer realized that in the long run it pays to get the injured employees back to the plant as soon as they are physically able and followed the practice of placing slightly injured sewing-machine operators on bench inspection work on a daywork basis, until they were able, by reason of their complete recovery and removal of their bandages, to resume their regular duties.

The incidental cost was computed as follows:

Lost time of 90 injured employees (1 hour each at 50 cents per hour, 2 hours each at 25 cents per hour)	$90
Lost time of ten injured employees (4 hours each at 50 cents per hour, 8 hours each at 25 cents per hour)	40
Time spent by foremen and supervisors (½ hour for each accident, at $1 per hour)	50
Repairs to machines damaged by accidents	25
Lost time of other employees who stopped work to assist or sympathize or out of curiosity (this includes 15 minutes lost by two employees, at 50 cents per hour for each accident)	25

In order to avoid spectacular and debatable elements of cost. figures on loss of production are not included in this example.

Case 9

Total cost of compensation and medical aid	$ 22
Total additional incidental cost, paid directly by the employer	107

An operator of a hot drop-forge press received an eye injury caused by flying hot scale. He was a skilled workman, and the assistant foreman was obliged to substitute for him for a period of three days, so that an important order could be filled on time.

The incidental cost was computed as follows:

Cost of time lost by employees who depended upon the assistant foreman for advice and instruction..........	$50
Cost of time lost by the assistant foreman, in addition to that which he would have spent in supervision as indicated by foregoing item...........................	30
Cost of time spent by the safety committee in the analysis and investigation of the accident....................	12
Cost of time lost by the injured man (paid by the employer)...	10
Cost of time lost by other employees when the accident occurred...	5

This example illustrates another point in incidental cost—namely, that in filling the gap caused by an injured employee's absence, and in maintaining production, other important work is often neglected.

Consideration of the hidden cost of accidents is often of value in directing attention to the need of plant improvement in its various phases. The four examples that follow[1] clearly indicate that lighting conditions should be improved for efficiency, economy, and safety.

Examples of Accident Cost Caused by Poor Illumination.—Consider, briefly, four accidents due to poor lighting, and the proportion of the cost borne by the insurance company and the employer, respectively:

CASE 1

A number of foundry workmen were engaged in tamping sand into molds or flasks. Because of limited space, it was necessary to stack the flasks in tiers, close to an industrial-railway track, until they could be transported to the casting department. A motor, pushing a number of small flat cars, ran against a stationary upright-ingot car. The lighter weight flat cars buckled laterally into a V shape, collided with the tiers of prepared flasks, and toppled them over. One of the flasks, in falling, grazed the leg of a workman and caused a slight skin abrasion. This necessitated a trip to the first-aid room, but the workman lost no time other than this, and no compensation was paid.

[1] SIMPSON, R. E., "$10,000 for Lighting or Accidents?" *The Travelers Standard*, vol. XVIII, No. 5, May, 1930.

There was some damage to the track and the cars, and the molds were so broken up and disturbed that the entire forming process had to be repeated. The cost of making repairs, retamping the flasks, and changing the schedule in an effort to save part of the molten steel that had been prepared for pouring amounted to over $1,000.

In this case, the lighting consisted of a faint degree of illumination from dust-covered overhead lamps, supplemented by a few local lights. A 100-watt bare Mazda lamp was suspended about seven feet above the ground, at the point where the flasks were assembled and tamped. This lamp was about 15 feet from the railway track, and the shadow cast by the tier of prepared flasks hid the heavy stationary ingot car from the motorman's view. Clearly, then, the lack of adequate illumination (or the prevalence of deep shadow) was the chief cause of this accident.

Case 2

The scene of another accident was the first floor of a building under construction. The windows had been boarded up, and the illumination was provided by a few unshaded lamps. A narrow ramp gave access to the first floor, which was four feet above the street level. At the right of the ramp was a large floor opening, and directly under the opening, on the floor below, workmen were engaged in installing machinery. There was a wooden rail guard, one inch by three inches in cross section, between the ramp and the opening. A laborer, pushing a wheelbarrow loaded with a radiator, took a half-running start to negotiate the ramp, and the wheel struck a two-by-four piece of wood with such force as to cause the radiator and barrow to break through the guard rail and fall on the machinery below. Fortunately, the radiator missed the workmen, but the barrow handle struck one of them and broke his collarbone.

The compensation claims and medical fees amounted to $147, and the irreparable damage to the machinery and the delay in finishing the building cost the owner over $4,000.

There was no artificial-lighting source within 25 feet of the ramp, and the natural light was excluded by the boards that covered the window openings. It is reasonable to suppose that if there had been sufficient light to disclose the two-by-four obstruction, the laborer would have removed it before attempting to push the wheelbarrow up the ramp.

Case 3

Two accidents that occurred in metal-working shops were almost identical as to cause and result. In one case, local drop lamps with pear-shaped reflectors were used to direct the light on to the points of operation of the machines. There was no overhead lighting, and the local lamps provided little illumination in the aisle between the machines. A department runner, carrying a box of bolts on his shoulder, failed to see an obstruction in his path, because of the lack of light, and stumbled over it. The bolts were strewn promiscuously on and about the machine and on the floor, and before the operator could grasp the situation and shut off the power, one machine, less than a year old and costing $3,500, was utterly ruined. The department runner received injuries in the form of a badly crushed ear and a cut cheek, when the box came in contact with the machine. The cost to the insurance company for medical attention was $32.

Case 4

The fourth accident occurred in connection with a battery of six semiautomatic group-driven machines. Repairs being necessary, the power was shut off, and two workmen started to disassemble one of the machines. At the same time, another workman, who was engaged in cleaning and oiling the remaining machines, needed a certain tool with which to make a minor adjustment. When reaching for this tool he accidentally closed the safety power-controlling switch, thus starting all the machines in the group. Before the power could be shut off or a warning given, the two men working on the partly disassembled machine were injured—one had part of a finger severed, and the other received a flesh cut on his arm and a badly bruised foot.

The compensation and medical charges for the injured men amounted to $317. The disassembled machine was damaged so badly that it was necessary to send it to a shop for repairs, and these repairs, plus the loss of production on the idle machines and the expense resulting from the interruption of the operating schedule, cost the employer over $1,700.

One 100-watt bare Mazda lamp was suspended just above the working level of each machine, in such a position that after a short time the man doing the cleaning became partially blinded by the bright light. Furthermore, the lamp was so located that the frame of the machine cast a shadow on the safety-switch box. In order to get the required tool, the cleaner was obliged to depend on his sense of touch rather than his ability to see and consequently grasped the wrong handle. Even so, the act of taking down a tool and that of closing a safety switch are not identical, and the fact that he did close the switch may be attributed to automatic or reflex action.

Here, then, are the stories of four accidents, and the industrial-accident record of each day furnishes the material for hundreds of others just like them—not with such uniformly high penalties to the employer or such light penalties to the insurance carrier, but nonetheless exacting a heavy toll which, in the end, the consumer must pay. There are millions of individual cases of violations of safe lighting conditions in industry today, and each violation means increased hazard.

The Cost.—A sum in excess of $10,000 was the total hidden or uninsurable cost of these four accidents—a sum sufficient to purchase 250,000 kilowatt-hours of electrical energy for lighting, at four cents per kilowatt-hour. It can well be imagined that the managers of these four plants would be disturbed by the thought of $10,000 added to their combined lighting bill. This would *seem* a new burden, but actually no new load would be placed on them. The costs had been there right along but had been buried in such items as upkeep, maintenance, allowance for depreciation, and general overhead—where they do not belong—instead of being debited to accidents or poor lighting, where they do belong.

This sum of $10,000 would have paid for additional electrical energy, which, if properly applied, would have adequately lighted any one of these plants for ten years, or all of them for two and one-half to three years. In that time, in all likelihood, the accident experience would have been such as to bring about a substantial reduction in the insurance premium, production would have been increased and spoilage decreased. Instead, the money was spent with nothing creative to show for it—merely damaged apparatus restored to its original condition.

The lesson to be derived is that economizing on the lighting bill at the expense of safety or production is not saving. It does not reduce expenses—but actually increases them.

Spectacular Examples of Hidden Accident Cost.—The examples of hidden accident cost given in this chapter include no fatalities, major dismemberments, or major permament injuries, nor do they feature spectacular costs that result from trivial injuries. Such omission is deliberate and does not affect the ultimate cost ratio. To be sure, there are many fatalities resulting in a direct cost of thousands of dollars against a relatively small incidental cost. (In one such, an employee who was about to be discharged for loafing fell from a wall and was killed.) On the other hand, there are just as many cases, or even more, where a minor accident costing but a few dollars in compensation or medical aid has caused an incidental loss of staggering proportions.

For example, an employee of a steel-construction contractor was tending the guide rope while a huge steel girder was being hoisted. He stumbled, bruised his shin, and lost his grip on the rope, and the girder swung around and struck against a column. The shock displaced the clamps, causing the girder to tilt, slip, and crash down upon a sidewalk shed, demolishing a section of scaffolding in its descent and damaging a hoisting engine seriously. The resultant property damage and delay cost the contractor several thousands of dollars over and above the medical cost of treating the employee's bruised leg.

Accident cost in the aggregate, as measured by compensation and medical payments, is made up of the greater volume of low-cost minor injuries, rather than the lesser volume of high-cost fatalities and serious injuries.

Were it fair to do so, an apparently stronger defense for the four-to-one ratio could be constructed by citing cases such as the following:

1. A premature quarry blast, set off inadvertently by an employee who became startled by a slight injury, resulted in serious damage to six drill rigs and a steam shovel. This equipment was buried under tons of rock, and the total loss was over $10,000.

2. The flooding of a tunnel occurred as the direct result of a minor accident. The loss amounted to over $25,000.

3. A slight injury to a lineman caused him to drop a coil of wire, which resulted in a short circuit. This led to claims against the power company and a loss of several thousand dollars.

4. An injury to an engineer, who was adjusting the stuffing box of a large steam engine while the engine was in operation, caused him to drop a wrench into the path of the moving crosshead. The cylinder head was broken, and the engine was thrown out of alignment and badly wrecked.

5. An explosion of a japanning oven (loss $17,000) was the result of an error on the part of a workman whose attention was diverted by a minor accident.

From further research the following conclusions have been drawn:

1. The ratio of incidental cost to direct cost tends to increase.
2. The incidental cost of all noncompensable accidents is about one-half the total direct cost of all compensable accidents. These accidents are of a type not usually reported, either to state compensation boards or to insurance companies. Case 3 well illustrates this point (see page 55).

Although 11 hidden accident-cost factors have been specifically listed in this chapter, it should be emphasized that, in calculating the ratio of four-to-one between hidden and direct costs, only a few of the factors were employed, these being the ones for which data were readily available. This fact, coupled with the omission of cost calculations for spectacular accidents that resulted in huge hidden costs, fortifies the main argument. Circumstances such as those specifically described in the examples might not prevail again, but others similar to them are likely to arise with considerable frequency.

The accident statistician will undoubtedly observe that the estimates from which conclusions have been drawn include, as cost to the employer, part of the wages paid to injured employees while they are employed at reduced efficiency, during recovery. This inclusion is proper in view of the general practice of getting the injured employee back on the job as soon as possible, not only because he otherwise represents an idle investment but also because there is often a possibility of malingering and of false and exaggerated claims.

SAFETY AND PRODUCTION

If any further corroboration is required of the assertion in this chapter that, aside from the humanitarian viewpoint, accident prevention has an additional incentive in the form of financial return, it may be found in the conclusions drawn from a study of *safety and production.*[1] This study was made by the Committee on Safety and Production of the American Engineering Council, which, at this point, is answering two questions, identified in the text as numbers 6 and 7, as follows:

"Does a positive correlation exist between the safety performance and the efficiency of production?

"Is the safe factory the efficient factory, and the efficient factory the safe factory?"

The complexity of the factors affecting productivity on the one hand and safety on the other has already been pointed out. Furthermore, as observed by Mr. Whitney in his statement of the problem, industrial conditions during the major period for which production data were obtained were far from static; in most industries there was not only actual pressure for production, but also rapidly changing conditions of production. Increased productivity, therefore, might be the normal outcome of better and more efficient management and equipment or might be the result of forcing the industrial organization and equipment even beyond the point of most efficient production. As a matter of fact, it may be conjectured that in any industrial group both conditions would be present at one time or another during the period.

The distinction between industrial productivity and industrial efficiency should be kept in mind, since the terms are not synonymous. Productivity relates to the output of the machine or plant in a given time without respect to the input of material, labor, power, or managerial effort; efficiency seeks to express the relation of output to input. In the case of a simple mechanism, efficiency may readily be measured and expressed, but in the case of an industrial plant, where the factors of input are expressed in wholly different units which cannot precisely be evaluated or reduced to a common denominator for purposes of summation, efficiency cannot be computed mathematically; in fact, we know of no established formula which could be applied to express accurately industrial plant efficiency. Even if such a formula existed, it is highly improbable that, in an extensive assay such as this, information could be obtained from the field which would reasonably permit its use.

The thesis that is under consideration, it is true, has to do with a third factor—executive control. Since information on efficiency per se could not be obtained, the best substitute appeared to be that factor which most accurately reflected the effect of changes in efficiency. Production rate on the basis of man-hours worked was selected, not

[1] "Safety and Production," pp. 28–37, Harper & Brothers, New York, 1928.

only for the latter reason, but because it was directly comparable with the accident frequency and severity rates.

Although increased productivity in a given plant might be secured at the expense of over-all efficiency and also of safety (just as a steam boiler may be forced above its rated capacity at the expense of efficiency and, ultimately, of safety)—and, inversely, decreased productivity might not be indicative of decreased efficiency—it was felt that increasing productivity in a large industrial group would almost certainly indicate the existence of an increasing industrial efficiency. Then if it could be shown that a preponderant proportion of cases showed either increased production rates accompanied by decreased accident rates or decreased production rates accompanied by increased accident rates, the existence of a high degree of correlation would be indicated.

Tables 1A to 1H[1] show the general behavior of the rates of the various industrial groups from which satisfactory data were collected. The totals of these eight tables may be combined according to the nature of the implied correlation as follows:

Number of employees in factories in which production rate was *Increasing* and accident rate *Decreasing* (Tables 1A and 1B)	845,631
Number of employees in factories in which production rate was *Increasing* and accident rate *Increasing* (Table 1E)	72,200
Number of employees in factories in which production rate was *Decreasing* and accident rate *Decreasing* (Table 1F)	7,754
Number of employees in factories in which production rate was *Decreasing* and accident rate *Increasing* (Table 1H)	7,377

Using "safe" to express decreasing accident rates and "productive" to express increasing production rates, it can be stated that, while among "unsafe" factories there are only ten (measured in number of employees) which are "productive" against one that is "unproductive" among "safe" factories the ratio is 109 to 1. This may be paraphrased by stating that a "safe" factory is 11 times more likely to be "productive" than is an "unsafe" factory.

The result leads unmistakably, however, to the implication that there exists a high degree of correlation between industrial safety and indus-

[1]Tables 1A to 1H as given in "Safety and Production" are not quoted inasmuch as their combined totals are sufficiently descriptive for the purposes of the text.

trial productivity and that the combination of low accident rates and high production rates is possible of attainment by any industrial group.

In the safety movement, the thesis that the safe factory is the efficient factory has been used for many years as the probable or possible brigading of these two factors, but without much support by way of facts. The committee believes that the principal thesis presented for its investigation has now been amply supported by the result of its investigations. It is of the opinion that a positive affirmative answer may be given to Questions 6 and 7; in other words, *that there is a positive correlation between safety and efficiency of production and, in general, the safe factory is the efficient factory.*

An examination of costs was not a major purpose of the study, yet certain cost figures were developed by the reports on individual accidents. The significant fact is the incidental or accompanying cost of all accidents, including those which are usually classed as minor. This cost or loss is usually disregarded, although it is unquestionably an important item in any accident experience.

Detail Findings.—By way of summary, the indications of the report have been tabulated in a group of detail findings and general recommendations. These follow:

1. Industrial accidents can be controlled under modern conditions of highly efficient productivity.

2. The rate of change in production per man-hour for the industrial groups studied is greater than the rate of change in accident frequency per man-hour or the rate of change in accident severity per man-hour. Quantitatively, the production rate was 14.4 per cent higher in 1925 than in 1922, the accident-frequency rate 10.4 per cent lower in 1925 than in 1922, and the accident-severity rate 2.5 per cent higher in 1925 than in 1922.

3. *The experience of a large group of companies shows that material reductions in accident rates can be obtained simultaneously with an increase in production rate.*

4. Major industrial executives have as much responsibility to initiate accident prevention as to initiate improvement in productivity.

5. *Efforts to improve safety performance do not interfere with production.*

6. *Maximum productivity is ordinarily secured only when the accident performance tends toward the irreducible minimum.*

7. The production and accident performances of the best plants in each industry studied clearly show that tremendous improvements can be achieved by the majority of plants in each industry.

8. *The incidental or accompanying cost of industrial accidents is a loss in industrial operation which should not be neglected.*

9. Organized safety work is being carried on in a relatively small percentage of industrial plants.

10. A large number of industrial establishments keep no accident records and make no attempt to analyze their experience as the first step in decreasing accidents.

Recommendations of the Committee.—The Committee on Safety and Production recommends:

1. That the same executive direction and control be given to decreasing industrial accidents as is given to increasing productivity.
2. That those agencies that collect and disseminate accident statistics adopt uniform terminology and standardized records so that all data will be compiled on a nationally comparable basis.
3. That the executives of those plants having high accident-frequency and accident-severity rates initiate, direct, and control ways and means of lowering such rates to at least the low rates obtained by other plants in their industry.
4. That industrial trade associations, engineering societies, and other agencies concerned with the improvement of industrial operation bring to the attention of their members the necessity of improvement in safety performance as a vital step in the strengthening of their industrial position.
5. That industrial trade associations secure, compile, and analyze accident statistics for the purpose of determining the lowest accident rate possible of attainment for their respective industries.
6. That industrial trade associations endeavor to secure such action on the part of executives of their industries as will result in each plant having the lowest accident rates obtainable.

Action in line with these recommendations will bring in a new safety movement which will far eclipse the old. There are hidden sources of strength in executive control which hitherto have not been applied to the accident situation. If American industrialists will adopt the same executive policy toward safety which they have fully developed toward production, we may confidently expect a decreasing number of deaths, permanent disabilities, and temporary disabilities, with their attendant costs.

Significance of the Report.—The committee feels deeply that the situation presented by this report, the remedial measures recommended, and the improvement clearly possible deserve the thoughtful consideration of industrial executives. Industry is admirably efficient, its achievements are a source of justifiable national pride, but its processes must be freed from inexcusable human wastage. Its operation must no longer accumulate a preventable cost in human lives and curtailed energies. When these losses and costs have been eliminated or brought down to the irreducible minimum, then and then only will the highest productivity be secured and the most efficient operation realized. The dynamic force which can attain this highly desired objective resides in the management. Therefore, a responsibility that cannot be evaded rests upon the managers and executives of industry to make safety a major interest and a continuing care.

In thus fixing responsibility so definitely, the committee does not place any blame whatsoever for conditions as they exist or for any aspect of the present situation. It does seek, however, to show where lies the responsibility for initiating imperative improvements.

CHAPTER III

CREATING AND MAINTAINING INTEREST IN SAFETY

The creation and maintenance of interest, as a first principle of accident prevention, applies to employers as well as employees. This book, however, is directed to the attention of individuals who initiate and direct safety work and who therefore are responsible for selecting the activities that are to comprise the plant safety program. These persons are the employers, the industrial executives, and the directors of safety. This chapter, therefore, is confined chiefly to methods whereby such persons may create, stimulate, and maintain the safety interest of employees.

It is characteristic of human behavior that the interest of a person may be aroused by appealing to one or more of his stronger senses or desires, such as self-preservation, loyalty, pride, or responsibility. The amount of interest thus created in an individual varies according to his reaction to the kind of appeal that is made.

For example, a machine operator who subconsciously fears personal injury may be induced to keep a guard in its proper place on his machine if an appeal is made to his fear of being injured. This man may have little interest in protecting the property of his employer or in the safety of his fellow employees or in the safety record of his department. If, however, he is deeply concerned with regard to his own safety and is also operating a dangerous machine, he can be persuaded to keep a guard in place on the machine.

Conversely, another machine operator may scorn fear of personal injury and in a spirit of bravado may deliberately expose himself to danger if self-preservation is featured too strongly or too obviously. However, this employee may take pride in the safety record of his department. If so, he too can be made to keep his machine guarded, if he is approached in a way that appeals to this side of his nature.

Another individual may have a strong tendency to "follow the leader" and to conform to the practice of the majority. In his case interest in safety may be aroused by pointing out that the maintenance of machine guards is the customary and general practice followed by other employees. The spirit of "team play" is strong in many individuals.

Of course, keeping guards in place is but one of the many phases of industrial-accident prevention in which the work of creating and maintaining interest is a vital factor. Even more important is the part that an employee plays as a member of a safety committee, or a leader in safety meetings, in accident investigation, in finding and reporting unsafe practices and conditions, and in many other activities. The necessity for individual interest, however, and the methods of creating and maintaining it, are fundamental with respect to all phases of industrial safety.

Naturally a person who is keenly interested in accident prevention will play a more constructive part in a safety program and will be less likely to be injured or to cause injury to others than one who is indifferent. The interest of individuals may be aroused and maintained by making use of known incentives. Those of chief significance are here listed, and they are commented upon in subsequent paragraphs:

1. *Self-preservation* (fear of personal injury).
2. *Personal and material gain* (desire for reward).
3. *Loyalty* (desire to cooperate).
4. *Responsibility* (recognition of obligations).
5. *Pride* (self-satisfaction and the desire for praise).
6. *Conformity* (fear of being thought different from others).
7. *Rivalry* (desire to compete).
8. *Leadership* (desire to be outstanding).
9. *Logic* (special ability to reason).
10. *Humanity* (desire to serve others).

It is probably true that all the foregoing motivating qualities or characteristics are present to some extent in almost everyone. It is also true that some of them will be more pronounced in certain individuals than in others. Therefore, the task of the safety director who is confronted with a problem of creating and maintaining interest is, first, to determine which particular characteristic predominates in the individual or groups of individuals whom he desires to interest and, second, to plan his program so as to make use of the knowledge thus obtained. This requires an understanding of human nature no greater than that which is usually possessed by industrial executives and supervisors. An observant foreman will note the reactions of employees when encouraged, instructed, admonished, criticized, or praised. The good foreman prides himself on his ability to know his men and to get the best results from them. Instinctively, perhaps, he often selects methods that appeal to an individual through that individual's predominant motivating characteristic.

It is efficient procedure to recognize and identify predominating personal characteristics as far as possible and consciously to adopt specific methods of approach, rather than to rely upon arbitrary or "hit-or-miss" methods. The safety director or foreman who knows which particular qualities are strongest in the individuals under his control is in a good position to reach his objective in accident prevention with less effort and greater speed than when he proceeds without regard for personal receptiveness.

Some of the factors to be considered when making a choice of the foregoing characteristics are: home conditions, financial status, health, age, sex, race, tastes, hobbies, habits, likes and dislikes, disposition, character, prevailing moods, temperament, and reaction to various happenings, as well as the degree of attention given to oral and visual methods of educational approach.

Selection of the means of approach to a worker's interest may be likened to a salesman's plan for arousing the interest of a potential customer. For example, the man who must support a wife and children will undoubtedly have a far stronger sense of financial responsibility than one who has no dependents. The young ne'er-do-well who previously was an accident problem, will be found to become interested in the "economics" of accident prevention when he starts planning definitely *for his own home.* The alert safety director will be alive to these changes in attitude and take advantage of them in carrying on his work of creating and maintaining interest.

Interest in self-preservation often increases following a serious injury to one's self or a fellow worker or some other well-known person. The desire for financial gain is stronger in the man who is buying a new home or an automobile on monthly installments. The spirit of conformity frequently is strong in recently arrived immigrants of the better type. Pride, the desire for leadership, logic, humanity, and rivalry, or their absence, are readily observed in most persons. And so the foreman or the safety director who depends on his powers of observation, common sense, and good judgment will come to know his men; he will recognize the opportunities for special appeals and will select methods of appeal best adapted to secure favorable results.

1. Self-preservation.—The first of the qualities or characteristics (self-preservation) listed in this chapter is the strongest and most common of all. In the case of certain individuals having underdeveloped mentalities, this characteristic is often the only one that may be appealed to successfully. Some of the more common methods of creating and maintaining interest through knowledge of this characteristic are:

a. Featuring the Injury.—Posters may portray serious bodily injuries. They may show the loss of arms, legs, hands, fingers, eyes, the results of infection, hardships from the loss of income, and many other unfortunate circumstances. Failure to report minor injuries can be associated with serious health impairment. Contrast can be drawn vividly between persons having full strength and vigor and those physically impaired whose ability to work, earn wages, and enjoy life consequently is reduced.

b. Accident Incidentals.—Crutches, glass eyes, broken safety goggles, the beggar's tin cup, the hospital cot, the operating room and its paraphernalia, and many other things associated with accident occurrence can be played up with advantage.

Methods of appeal that feature the injury and the accident incidentals, such as described above, need not be confined to posters and notices but may include oral discussion at meetings and lectures. Lantern slides and moving-picture films also may be used.

It should be understood that emphasis is not being placed here on the *desirability* of featuring bodily injury and accident incidentals. As has been pointed out, the appeal to the instinct of self-preservation is only one of the many methods that may be utilized in creating and maintaining interest. Further, it is suggested that this particular method be used only when it fits a specific case. There is much to be said in opposition to gruesome posters although use of this approach is defensible under certain conditions.

Example.—In a hardware-manufacturing plant, accident frequency was quickly controlled when it was discovered that the majority of employees were susceptible to an appeal that was directed to "fear of injury." In this case, previous efforts of a general nature featuring competition, awards, etc., had been unsuccessful.

Infections from relatively minor injuries on screw-cutting machines constituted the chief problem.

The method of approach was to minimize the emphasis on numbers and cost of accidents, on poor records, and on lack of skill, etc. In lieu thereof, advantage was taken of all opportunities to feature bodily injury, up to but not including gruesomeness.

Posted notices described the results of accident occurrence as "serious infection," "loss of use," "painful lacerations," "mutilation of fingers," "crippling of worker," etc. Posters and films were shown depicting infected areas on arms and legs, resulting from neglect of minor injuries.

The chairman of the safety committee used similar terms and illustrations in his discussions. Accident records were arranged so as to emphasize the *injury* rather than the *accident*, and in many other ways the entire oral and visual tone of safety work was altered so as to appeal to the selected predominating characteristic of "Self-preservation."

2. Personal and Material Gain.—Many persons are more than ordinarily desirous of financial or other forms of material and personal gain. It is often true, therefore, that interest in safety may be created by associating a reward of some kind with recognition of outstanding safety performance. Here are a few ways in which this may be done:

a. Bonuses.—Monetary rewards may be given for good safety records.

b. Salary Increases.—The possibility of a raise in salary is a powerful incentive. Certain types of employment plans—such as civil service—may map out a lifetime service career showing promotions and other benefits that result from a satisfactory record. It can be pointed out that accidents interfere with continuity of service and with the rewards that such service provides. More directly, quality and length of service may be coupled with an accident-free record, when the employee is considered for promotion or salary increase.

c. Vacations with Pay.—These may be given to individuals or to whole departments on the basis of outstanding accident-free performance.

d. Days Off.—Rewards can be given in the form of occasional days off.

e. Trips.—Trips to safety conferences may be offered. These help to maintain interest in the job and also provide opportunity for obtaining safety instruction.

f. Personal Gifts.—Interest in a planned safety program or contest can be stimulated by awards of small personal articles such as billfolds, belt buckles, knives, and pencils.

g. More Desirable Types of Work.—Some plans include assignment to jobs providing steadier or more desirable work, and these assignments are made as rewards. Many desirable jobs *necessitate* the employment of safe workers.

h. Banquets and Picnics.—These form a convenient method of rewarding groups of employees for good records and have the added advantage of improving morale.

i. Appointments to Safety Activities.—A place on the safety committee may be made to appear highly desirable and to appeal to certain employees. Other appointments may be made as rewards for safety performance.

It is generally agreed that best results are secured when employees practice safety for safety's sake, and not, primarily, for gain. Thus, when awards are given, it has been found desirable to impress upon the employees the point of view that prizes are given not only to reward past safety performance but also to encourage and stimulate future active interest in the elimination of mechanical hazards and unsafe personal practices.

Some employers are of the opinion that prizes and bonuses for good no-accident records are unwarranted—that by his very acceptance of a job, an employee automatically is obligated to work carefully and safely. Theoretically, this is true. But as long as human nature remains what it is, the judicious granting of awards for safety will often produce results that perhaps could not be attained by any other means. Especially is this true when the employees who are approached are more than ordinarily susceptible to appeals that are directed to their desire for personal gain.

Example.—The sales department of a nation-wide concern dealing in gasoline, lubricating oil, and various by-products, became greatly concerned because of the increased number and greater severity of salesman-driver automobile accidents. Equipment was satisfactory, traffic conditions were normal, and the drivers were selected with due regard to previous experience, physical condition, and general attitude. A detailed and carefully planned safety program existed. In fact, all endeavors were conducive to a good accident record, except that the majority of the drivers were not sufficiently interested in safety to observe safe-practice rules constantly. Methods of approach, selected arbitrarily, had been used with little success. These had consisted of the imposing of penalties and of an educational campaign that utilized safety posters, safety movies, and inspirational talks. The management was opposed, on general principles, to the awarding of prizes or bonuses, and believed that inasmuch as safe driving was an expected normal practice, it was improper and unnecessary to treat it as though it were something unusually meritorious.

However, when the service engineer of the insurance carrier substantiated the assertion that many of the drivers were more than usually susceptible to appeals based on monetary awards, management resolved to adopt new tactics. Although it was known that the *principle* rather than the intrinsic value of an award should have the most influence, it was believed that in this case at least, cash prizes would be valued more highly than buttons, badges, or certificates.

Therefore a plan was adopted, the details of which were given publicity, and dates were set for the beginning and end of the first period under which the plan was to operate. The plan involved little that was novel except the manner of distributing the awards. At the end of the first period all the drivers, regardless of their performance records, in each of the several districts, were invited to a dinner presided over by the respective district sales manager. Procedure at each location was similar.

The special fund provided by the company amounted to one dollar for each driver. The total amount, in silver dollars, was placed in a conspicuously located clear-glass bowl at the speaker's table. After appropriate remarks, the driver having the best no-accident record was invited to mount the platform, reach into the bowl with both hands, and withdraw, as a prize, as many silver dollars as he could hold. The construction of the glass bowl, particularly with regard to the orifice at the top, was such that it was somewhat difficult to withdraw both hands simultaneously, and this led to much juggling and good-natured wise-cracking on the part of the audience. Invariably, however, the driver came away with a substantial prize. The four next best drivers were given a similar privilege, except that each was restricted to the use of one hand. Other drivers having fairly good records were given from $5 to $1 each, and the chairman expressed the hope that at the end of the next period all the remaining drivers would be eligible for cash awards. It developed that the sum of money involved was relatively small, and, best of all, this appeal to the desire of the employees for personal and material gain resulted in the awakening of a far keener individual safety consciousness, a substantial decrease in frequency and severity of accidents, and, ultimately, a reduction in insurance and other operating cost.

This example is not intended to typify original or specifically recommended methods of awarding prizes but rather to illustrate the assertion that the response of employees is far more likely to be favorable when they are approached with knowledge of the particular characteristics to which they respond most readily.

3. Loyalty.—A well-developed sense of loyalty, plus an understanding and approval of safety rules, usually ensures observance of safe-practice rules. Some of the more common ways of creating and maintaining interest in safety, when the employee's sense of loyalty is well developed, are as follows:

a. Effect of Accident Occurrence on Foreman's Record.—The employee can be shown that his failure to perform his job safely reflects on his foreman's record.

b. Effect of Accident Occurrence on Employer's Overhead Cost.—It can be explained that injury to the individual employee increases the plant overhead cost.

c. Effect of Accident Occurrence on Quality of Employer's Product.—The employee can be shown that his unsafe actions not only may reduce the volume of production but also may result in output of inferior quality.

d. Effect of Accident Occurrence on Fellow Employees.—Employees who are loyal to their fellow workers are averse to the continuance of unsafe practices that cause accidents and thus spoil the safety record of all other men in a given group or department.

e. Supporting the "Boss."—Accidents occur largely from violation of common-sense safe-practice rules issued by the "boss." Loyal workers prefer to support the managerial and supervisory staffs and if appealed to on this basis will themselves obey the rules and can be induced to set an example that less loyal employees may follow.

Example.—In a plant department having a poor accident experience, several attempts to enlist the interest of the workmen in accident prevention had failed. Scare posters, showing the results of accidents from both a personal-injury and a personal-economic standpoint had been tried, films and inspirational speakers had been used, and even a costly "safety slogan" contest had been carried out, all with indifferent success.

A majority of the employees in this department were of the same nationality and of a very clannish nature. The foreman too was of the same nationality and held important community and fraternal positions among his countrymen.

It was explained to the employees of this department, especially to those who were most prone to commit unsafe practices, that unless the accident experience of the department improved it would reflect seriously on the foreman's record. In fact, the rumor got around that unless improvement was made shortly, a new foreman, unknown to all of the men in the department, might replace their present boss.

Needless to say, the response was immediate. Once his loyalty had been appealed to each friend of the foreman rallied around, and the accident experience of this department not only improved but became the best in the entire plant.

4. Responsibility.—The sense of responsibility, both to self and others, is an attribute that is found to a degree in the great majority of persons. It also is one that is capable of being easily utilized to promote interest.

The "responsible" person will be inclined to work safely if he is shown that by persisting in unsafe practices he is likely, sooner or later, to cause an accident that will bring misery and economic loss to his own dependents, or to fellow workers or members of their families. Remorse is an emotion that no one, least of all the employee who fully realizes his responsibility, is desirous of experiencing, and the skillful dramatization of responsibility in connection with the aftermath of a serious accident is a powerful deterrent to unsafe practice.

Appeals may be made as follows:

a. Assignments.—Interest may be developed when additional duties in certain safety work are definitely assigned to persons in whom the sense of responsibility is well developed. These employees may be:

> Charged with the care, maintenance, and fitting of goggles, gloves, masks, safety shoes, and other safety equipment.
>
> Given charge of housekeeping in specified areas.
>
> Given the duty of keeping bulletin boards neat and putting up new posters.
>
> Appointed as chairmen of committees or leaders in other safety activities.
>
> Assigned duties in accident investigation and the keeping of records.

b. Analogy.—Responsibility for safe use of tools and equipment and for the observance of safe-practice rules can be compared to responsibility for the care of a family or a motor vehicle, and for the observance of rules for the family budget, for health, old-age security, etc.

Example.—A meat and grocery chain-store organization, finding that it was difficult to maintain the safety interest of its store managers, who are to a large extent the only steady personnel in these small stores, was encouraged to join with its insurance carrier in research intended to uncover the primary reason why these managers were so unconcerned. Certain interesting and justifiable conclusions were drawn. It was found, first of all, that because of the general nature of their positions the store managers were characterized by a strong sense of responsibility. In a chain store the manager of the store must act largely on his own responsibility. Although he is visited more or less frequently by traveling supervisors and superintendents, he is to all intents and purposes the "monarch of all he surveys." Upon further investigation it was also found that the majority of these store managers did not sense their responsibility for the prevention of accidents either to employees or to the public and as a consequence did not take continuous and specific action of any great value. The remark of one store manager was typical. When asked why he did not keep litter off the floors he said that in accordance with his understanding of his responsibilities, it was up to him to develop a satisfactory volume of profitable business, that as far as housekeeping was concerned he felt that he had discharged his obligations when he had lived up to posted rules to the effect that the floors were to be swept four times each day. Inasmuch as the reaction of this store manager was typical, the management obtained results in safety by issuing specific instructions placing directly on the store manager full responsibility not only for sales volume and other phases of business management but also for the occurrence of accidents and the elimination of conditions that caused them. Responsibility was featured for several months in the daily bulletins issued from the main office, in correspondence, and in periodical accident progress reports. The drive thus made was in this case successful almost entirely because of its appeal to the predominating characteristic (responsibility) of the store managers.

Many employees have erroneously believed that accident prevention was the responsibility of someone else, as of the boss or the insurance inspector, and the correction of this improper thinking will solve numerous accident problems.

5. Pride.—Pride in his work is one of the strongest incentives an individual can have for producing the best results within his ability. In many instances it is even stronger than reward or responsibility toward oneself and others.

Pride increases as achievement progresses and is often proportionate to the relative quality of the achievement, to the individual's personal recognition of the worth of his work, and to the degree to which the work has improved. The ability to experience pride, therefore, cannot exist unless the individual is willing to compare and evaluate. This characteristic may at times be evidenced even more strikingly in persons of lesser intelligence than in highly skilled individuals whose standards of achievement are difficult to surpass. A person who is capable of well-founded pride in his work is not necessarily also interested in the safety of his fellows or the safety record of his plant. Lucifer was proud, but Lucifer was profoundly antisocial. When dealing with a person who is proud of his own strictly material achievements, it may be necessary to demonstrate to him that the safety of the group with which he is associated is an important factor in his own accomplishments, and that safety, in the long run, is an aid to efficiency. Pride in *group* achievement often can be "sold" readily to an individual who already has pride in his personal achievements. Interest in safety may be stimulated through appeals to pride, in the following ways:

a. Praise.—Approval of good work is a stimulus upon which pride thrives. Congratulation on safe performance therefore is a successful medium of approach.

b. Exhibits.—Display of craftmanship is a form of showing the results of one's best abilities. Accident charts and statistics are exhibits of safety endeavor.

c. Awards and Insignia.—Pride in safety achievement is maintained by the use of cups, plaques, banners, and trophies for groups, and badges, buttons, and other similar insignia for individuals.

Note.—It will be observed that the awarding of prizes of material value appeals not only to pride but also to Number 2, "Personal and Material Gain." However, the emphasis in this case is not so much on the intrinsic value of the award as on its significance as a recognition of achievement.

d. Differentiation.—In some industries it has been found practicable to provide distinctive uniforms or hats or jackets for employees whose safety record is outstanding or who are members of a group or department that leads in safety performance.

Employees who have a well-developed sense of pride will frequently excel in performance when they are given a part in plant administration. An electric manufacturing company found this to be true in experiments carried on in one of its plants. A small "control" group of employees, all girls, was selected for research so that it might be determined which physical conditions were most conducive to highest production. When improved lighting was provided, production went up. When illumination was lowered, production went up again. When work hours were shortened, production went up as it did when rest periods were installed, when piecework was introduced, hot lunch was served, and other experiments were tried. The answer to this somewhat paradoxical situation was in the *attitude* of these girls. They had been told that they were helping management to make an experiment; they were no longer cogs in a machine but were helping to solve a problem. *They had pride.* And so they continually improved the speed and quality of their work, regardless of environmental circumstances.

Example.—In an effort to improve an unsatisfactory accident record, the director of safety in an iron foundry resolved to appeal to the employee's pride. His choice of this method was not "hit or miss" but was made because of his knowledge of two predominating employee characteristics. The personnel of the plant was of such nature that the majority of employees were inclined to follow the leadership of certain others who, for lack of a better term, may be described as "ring leaders." There were two men in this group who had shown evidence of pride in their ability as skilled workmen, also in their ability to lead and influence their associates. Knowing this to be true, the employer called these men into conference, one at a time. Inasmuch as they were valued employees, he could quite honestly compliment them upon their mechanical skill and ability. This he did and then proceeded immediately to compliment them also with regard to their qualities of leadership.

He then indicated that he wished to have them share with him one of the important plant problems, this being the prevention of accidents. In each case he was careful to point out the specific unsafe practices of the workers in the department of the individual with whom he was talking, but he did not make the mistake of belittling the difficulty of converting the violators of safe-practice rules to more common-sense and safe-practice procedures. As a matter of fact, he exaggerated the difficulties and found, much to his satisfaction, that this was accepted as a challenge. In each case the employee whose assistance was enlisted by appealing to his pride of accomplishment and whose vanity presumably was flattered, obtained a far more comprehensive viewpoint of accident occurrence and accident prevention. He also took it upon himself to study the situation in his department, with great care. He set a good example by his own performance and then influenced his associates to do likewise. An additional noteworthy feature in this case is that the individuals appealed to in the manner here described were so characterized by pride in achievement that they voluntarily reported progress to the director of safety. This provided further opportunities for deserved praise and kept the wheels of accident prevention turning in the right direction. This might be cited also as an example of appeal to an individual's sense of leadership (No. 8). Many of these motivating qualities will be found to overlap.

6. Conformity.—Through the years, the experience of the majority has proved that certain patterns of living are productive of the greatest degree of happiness, material well-being, and social harmony. Conformity with these patterns is necessary to the maintenance of any well-ordered civilization. The social and material values of morality, hard work, consideration for others, and observance of the golden rule are universally recognized, and the person who habitually flaunts established conventions in any of these respects is likely soon to find himself a social outcast. Fortunately, most persons realize this and are willing and even anxious to abide by established rules and customs. In cases where the sense of conformity is characteristic, the following methods of appeal can be used to create interest in accident prevention:

a. Standards.—The posting of safe-practice rules, codes, and approved procedures that are described as *standard* and *commonly accepted* by the majority of persons.

b. Comparison.—The violation of safe-practice rules can be treated as unpraiseworthy—an *exception* to a general rule.

c. System and Regularity.—Regularity of procedures and systematically conducted safety work in general are ot great importance where "conformity" is a predominating characteristic of employees.

(1) Fixing hours for cleaning and oiling machines.

(2) Definite and periodical practice of turning in defective tools.

(3) Scheduled days for safety-committee meetings.

(4) Emphasis on reporting minor injuries invariably to first aid.

(5) Featuring steps determined by job safety analysis.

d. Leadership.—Selection of a leader who will set a good example in safe conduct for the purpose of influencing employees who readily "conform" to commonly approved practices. (See example under No. 5, "Pride.")

e. Ridicule.—Inasmuch as the "conformist" fears ridicule, in certain cases it is advantageous to portray the violation of safe-practice rules not only as contrary to customary procedure but as silly or ridiculous.

Note.—This item is not one to be treated lightly, since it may be highly improper and defeat its own purpose in certain cases. It is included, nevertheless, because it serves to complete the picture of available methods.

The normal human being desires to follow approved practices in all his activities, both in his work and in his private life. It is therefore not difficult, as a rule, to secure his active participation in a concerted movement for safety, provided he is shown that the safety movement has the approval and backing of those persons whose leadership and popularity are unquestioned.

Example.—In the preceding example, reference is made to the fact that employees were inclined to follow the leader. This characteristic was utilized in a drop-forge plant, with beneficial results. The problem was to create sufficient interest in the wearing of safety goggles. Usual methods involving enforcement, penalties, persuasion, and education had been ineffective. It was determined, after a short study, that the employees were of a type that willingly followed *commonly accepted* procedures. A change in methods of safety administration was decided upon.

Unfortunately, in this case there were no employees in whom leadership was strongly developed, nor was it accepted practice on the part of any influential employee to wear goggles. Prompted, however, by knowledge of the characteristic mentioned above; namely, conformity, each executive of the plant, and certain of the employees that could be influenced more readily as well, agreed to wear goggles continuously whenever they were in the operating end of the plant. This was done deliberately and purposefully, even though the danger of eye injuries in certain operations was slight. Thus the employees became accustomed to seeing certain key individuals, at least, wearing complete eye protection. One by one they changed their attitude until finally the personnel, with very few exceptions, was converted to the use of suitable eye protection. An interesting feature in this case was that one of the executives who followed this self-imposed rule constantly, was one day walking across the plant yard when a small stone, thrown from the wheel of a passing automobile struck the lens of his goggle and cracked it. By his practice, assumed (as he thought) for the good of others, he had saved himself a painful injury.

7. Rivalry.—Man is a highly competitive animal. Laboratory tests have shown convincingly that certain persons performing various simple tasks accomplish better results when competing with others than when working alone. Their interest in what they are doing seems to increase in proportion to the opportunity for demonstrating the superiority of their performance as compared with the performance of others. There are few persons in whom there is not at least a dormant sense of rivalry. Where this characteristic is prominent, it may be appealed to in several ways.

Outstanding no-accident records usually result from long-continued efforts on the part of both management and employees and not from intermittent campaigns or contests. Contests, however, have been proved a most satisfactory device for restoring flagging interest and providing a much-needed tonic for "pepping up" a lagging safety program, and for overcoming staleness, matter-of-factness, and even occasional downright indifference.

In appealing to the sense of rivalry there are few approaches, although these have many different applications:

a. Provide Opportunity.—Rivalry requires opportunity to express itself, and such opportunity may be provided by the inauguration of safety contests or competitions. One department of a plant may compete with another, the entire plant may compete with other plants that are entered in a national or state-wide accident-prevention campaign. Opportunity may also be provided for the recognition of achievements by individual employees—perhaps by comparison with their own past records.

b. Set Up Objectives.—An objective or "bogey" can be established. It may be based on the number of man-hours worked with no lost-time accidents, on low severity rates, or on comparison with the past performance of comparable units.

c. Determine Method of Measurement.—Success depends in part on the adoption, in advance of the contest or competition, of a clearly stated formula or method of measurement. Those in common use are:

(1) The number of chargeable accidents per million man-hours worked.

(2) The number of chargeable accidents per 100,000 car miles or passenger miles (for vehicles).

Many variations of the above are often used. The definition of a chargeable accident may be modified to suit local circumstances. Frequency rates may be on a "per-man" or on a "unit-group-of-men" basis. Cost or severity, often the degree of responsibility, and factors representative of the severity of exposure, may be included as modifying elements in the method of measurement.

Example.—The applications that utilize the characteristic of rivalry are so common that a wide variety of examples could be presented. However, the particular method adopted by a dairy concern may be of interest. In this case, the customary records of each subsidiary were kept at the main office, and modifying factors based on past experience and current exposure were made a part of the accident-frequency-and-severity formulas, so that any subsidiary could be compared fairly with its competitors. Results were published periodically so that each branch was promptly made aware of its standing. Much publicity was given to the leaders and also to the subsidiaries that had improved their positions in relation to their competitors. Praise was extended to the first-place group—in an open letter by the secretary of the company, in one instance—when a month of exceptionally difficult driving was completed without an accident of any kind.

At the end of the year, it was customary for the president of the organization to issue an annual message. When it was made known to him that the accident record as a whole needed improving, and when this was coupled with the information that the subsidiaries were jealous of their standards as *business* producers, he came to the conclusion that they would probably be just as jealous of their comparative standings in *accident* prevention. He therefore included in his annual message a specific reference to those subsidiaries that had obtained outstanding results in safety and attached to his message a list in which the subsidiaries were arranged according to the order of their respective safety records.

The prominence that this specially worded annual message gave to accident prevention, coupled with its appeal to the characteristic of rivalry that was so pronounced in the subsidiary employees, led to the much-desired reduction of accident frequency and severity.

Although, in this particular instance, appeal was directed chiefly to "rivalry," the methods used to create interest also appealed in a lesser degree to material gain, loyalty, responsibility, conformity, and leadership. It is desirable, of course, to pick the best avenue of approach in creating safety interest, but it is often advantageous to utilize more than one form of stimulus, provided this can be done in a practical way.

8. Leadership.—The desire for leadership is strong in many persons and may be used to advantage in safety work. Every worker who knows correct safety procedures can exercise his liking for leadership by tactfully pointing out to careless or uninformed fellow employees the accident potentialities of their unsafe practices and by showing them the correct way to do things. Instructing seasoned workers to keep a watchful eye on the working habits of new employees appeals directly to their desire for leadership.

Employees in whom leadership is an outstanding trait may be interested in safety in the following ways:

a. Promotion.—The promotion of workers to supervisory or executive positions, because of safe performance coupled with other required characteristics, provides the opportunity to create interest in accident prevention through the inherent desire for leadership, and has the further advantage of associating safety with other phases of industrial work.

b. Additional Responsibility in Safety Work.—The gratification of the desire for leadership may be satisfied by appointments on safety committees, by assignment of the task of accident investigation, by membership on first-aid teams, etc. All these provide opportunities for making speeches, giving testimony, relating experiences, and acting as chairman of meetings, etc. Many opportunities of like nature exist in organized safety procedures.

Example.—As stated, the example given under the heading "Pride" serves equally well to illustrate the manner in which an appeal may be made through leadership. In certain cases, however, the quality of leadership may exist without pronounced pride. In one such case, the management of a granite quarry had difficulty with a skilled worker who could be described as a "conscientious objector" to safety in general. This employee, however, was so valuable in other ways that the management was unwilling to dispense with his services, yet his attitude was so improper that not only had he himself been involved in several accidents, with the prospect of more, but he also exerted a negative influence on many of his fellow employees. He was characterized by a strong sense of leadership and, as a matter of fact, had been considered several times for promotion because of this quality. However, he had not been given additional responsibility, chiefly because of his attitude toward accident prevention. In an effort to solve the problem the management decided to give him an opportunity to display his leadership, not, however, as a foreman but as a leader in safety activities. In short, they made him chairman of the quarry safety committee. Needless to say, this was done much against his own inclination. The results, however, were highly satisfactory and in view of his predominating characteristic they were actually to be expected. In carrying on his duties as chairman, this employee soon found that he had many opportunities to satisfy his ambition as a leader of others. He relished the opportunity to preside at meetings and to direct the discussion. This provided him with more information regarding the principles and the detailed facts of accident occurrence and accident prevention than he had heretofore possessed. This additional knowledge gave him a broader and a more favorable viewpoint. He became impressed with the inconsistency between his conduct as a safety-committee chairman and his own safety performance while at work and in a very short period of time improved his own attitude tremendously. Ultimately he became one of the foremost advocates and exponents of practical safety in the entire quarry operation and eventually rose to an important place in his organization. In this particular case, management thus found an opportunity to solve one of its most troublesome problems through its appeal to the quality of leadership.

9. Logic.—Some persons have a better faculty of reasoning than others and often take great pride in their ability to "see both sides of a question" and to arrive at conclusions that are logical and just. Such persons may be interested in safety to the point of correcting their own unsafe actions and taking a more constructive part in organized accident prevention if they are approached on the basis of facts and figures.

Facts are essential to the exercise of logic, and those of most importance when using the method of appeal under discussion deal with accident frequency and severity, causes, and remedies. Other facts may relate to the analogy between production faults and unsafe practices, also to skill as a factor in safety, and to the many obvious advantages of safe conduct in general. Statistics showing the good results that have been accomplished through safety efforts may be featured. Such statistics need not be elaborate or involved. It is preferable that they be easy to remember, sufficiently impressive to arouse interest, and that they provide definite proof of results accomplished by specific measures.

If a plant already has a good accident record and wishes to maintain it, the presentation of accident facts should be designed to show how safety efforts have resulted in an improvement, as compared with other similar plants or in the industry as a whole.

A few methods of appeal to logic are listed here:

a. Basic Philosophy of Accident Prevention.—Presentation of such basic principles as:

The occurrence of an accident is evidence of "something gone wrong," of an error or a miscalculation, an instance of inefficiency or of fumbling and bungling in general.

Accident prevention is a worth-while activity inasmuch as all its results are beneficial and desirable.

The majority of all accidents are of preventable types.

Personal unsafe acts cause the majority of accidents.

The correction of unsafe physical or mechanical conditions should be a first point of attack.

The safe way to do a given job is practically always the best and quickest way.

The unsafe worker penalizes himself and his family more than his employer.

It is part of the employee's unwritten contract with his employer that he obey the safe-practice rules of the shop.

The unsafe performance of one employee frequently endangers the safety of other employees.

b. Opportunity for Prevention.—Discuss the foundation of a major injury (see Chap. II, Section 4); the fact that the continual violation of a safe-practice rule inevitably leads to accident and injury and that such violations may be checked before the injury occurs.

c. Facts of Accident Occurrence.—Provide the facts of accident occurrence. Specify the particular unsafe acts and mechanical hazards of the local situation. Show that no accident can possibly occur unless some person acts unsafely, a mechanical or physical hazard is present, or a combination of these circumstances exists.

d. Provide Data Relating to Accident Frequency and Severity, Accident Types and Causes, and Remedial Measures.

Example.—In most trades and professions the nature of certain jobs is such as to demand a natural aptitude for reasoning. Where this requirement exists it can often be used to good advantage in promoting safety. A case in point is that of the tool-and-die department of an electric specialty manufacturing plant. Approximately one hundred skilled tool-and-die makers were employed. In order to do their work properly these men necessarily had to read blueprints, make calculations, make dimensioned sketches involving the application of plain and solid geometry, and do many other things, all of which placed emphasis on their ability to draw accurate conclusions and take action on the basis of established facts. Having found it necessary that interest of these men in accident prevention be created and maintained, and having found no other outstanding characteristic in this group of employees, the management decided to base its appeal to them on logic. Use also was made of the knowledge that these men persisted in unsafe practices because they were not convinced that it was dangerous to so continue. At a special safety meeting in this department the safety director made good use of "The Accident Sequence" as described in Chap. II. He placed on a blackboard a sketch showing a row of five dominoes, each one representing a factor in the sequence and so arranged that the fall of one domino would precipitate the fall of one adjacent to it. He then proceeded to prove that a compensable injury inevitably and invariably is caused by an accident, that the accident can occur only when an unsafe practice is committed or when a mechanical hazard exists, that the latter exists always because of the fault of a person, and that faults of persons are due to inheritance and environment. The safety director went to considerable length to explain the principles of accident prevention in detail. He gave facts and figures and expressed himself in terms of percentages and ratios. He showed charts and graphs. The men were found to be highly interested, so much so in fact that they became constructively argumentative.

This meeting was described afterward as one of the most interesting and resultful of all that had been held up to that time.

The situation may be described as one wherein accident prevention was brought to this particular group of men in their own language and in a way that appealed to them because its principles were just as logical as those that governed their work of making tools and dies.

10. Humanity.—In the earlier days of industrial safety effort, before it was clearly enough established that accident prevention was definitely "good business," many employers supported safety activity almost wholly because of humanitarian reasons. In those employers the humane characteristic was strongly developed. Such cooperation as they received from their supervisory staffs and from employees was also prompted largely by humanitarian motives. Where this most commendable trait exists, it may be used to great advantage in accident-prevention work, even though the sense of responsibility, fear of personal injury, personal gain, rivalry, logic, and other characteristics are relatively weak or wholly absent. Humanitarianism is a widely spread personal quality and should not be overlooked in the search for best ways and means of appealing to employees with regard to safe performance. Further, the humanitarian impulse is one of the easiest to enlist in the plant accident-prevention program. However, the plan should be directed toward the development of such mental attitudes and habits as tend to make the individual *foresee* accident occurrence and either eliminate the causes or guard against them at all times. It is better to point out the danger of accident inherent in a given situation before a person is dangerously exposed than it is to shout "Look out!" in the split second before disaster occurs. Interest in safety may be aroused through a man's sense of humanity by methods similar to those discussed under the heading "Self-Preservation" and also in the following ways:

a. Express Progress in Terms of Life and Limbs.—There is great personal satisfaction in having helped to prevent suffering in others. The humane person is stirred to a point of far greater cooperation if bare facts dealing with numbers and frequencies of accidents are supplemented or replaced by terms of human injury and suffering.

b. Save a Life Campaign.—Inasmuch as personal gain and commercial rivalry are not likely to be strongly developed motivating qualities in persons in whom the humanitarian quality is well developed, the tone of safety campaigns should feature the saving of lives and the prevention of suffering.

c. Feature First Aid.—Interest may be aroused by emphasizing first aid and by establishing first-aid classes under qualified instructors. The teaching of injury treatment to all employees has many times had remarkably good effects on accident records.

Example.—A cotton-spinning-and-weaving mill had a personnel that could be best described as "hard boiled." The employees, many of whom were women, were drawn from a not too desirable section of a typical mill town, and all previous efforts to interest them in safety had been fruitless. A simple investigation disclosed that the attitude mentioned above was really superficial and that the crude exterior of many of these employees concealed very humane impulses. Inquiry disclosed that the employees had voluntarily established a goodwill club and that they had made generous donations in case of illness and distress. These facts having been established, the management changed its method of approach although it did so with some misgiving.

The entire tone of safety educational publicity and of discussions at such safety meetings as were held, was changed. Emphasis was no longer placed on interference with production, on skill, pride, responsibility, and, least of all, on fear of personal injury. Instead, it was pointed out repeatedly that the practice of leaving spools and bobbins on floors not only was a violation of common-sense safe procedure but also frequently resulted directly in the fall of employees, in painful sprained ankles, and, in several cases, in broken legs. It was pointed out by management that two of the employees that were injured in a recent month were in such circumstances that they not only suffered because of the injury but also endured privations at home. In one case, the loss of full pay led to the seizure by a finance company of essential furniture possessed by the employee. These things and others similar to them were stressed by the management until at the end of three months a most agreeable surprise occurred in the form of a 45 per cent reduction in accident frequency and a corresponding improvement in severity, as well.

Conclusion.- In bringing this chapter to a close it is appropriate to explain that no attempt has been made to express the principles of either analytic or introspective psychology, nor are the preceding statements and suggestions based on professional knowledge of industrial psychology or psychiatry. The point of view is wholly that of the practical accident-prevention engineer, and the purpose has been to express in plain terms simple methods available to the layman who has only the average understanding of human nature and of mental processes.

It will be observed that no attempt has been made to describe methods of creating or stimulating dormant or nonexistent personal characteristics, notwithstanding that this would be eminently desirable. It is clear that accidents are far less likely to occur among employees that at one and the same time are fearful of personal injury, desirous of material and personal gain, loyal, responsible, proud, logical, humane, etc., than among employees in whom only one or perhaps none of these characteristics is strongly developed.

However valuable the effort might be, the direct attempt to develop such personal qualities does not come within the scope of this discussion, which deals primarily with the principles and simplified application of present-day industrial-accident prevention. For this reason the treatment of the subject is confined to the *finding* and *utilization* of *existing* qualities rather than to their development.

Space limitation prohibits greater detail as to methods of application. It is of interest to state, however, that these methods fall roughly into two groups, namely, oral and visual. Person-to-person conversation, talks at meetings and committees, and the giving of orders and instructions are as helpful when appealing to fear of injury as when appealing to pride, logic, or humanitarianism. The same thought applies likewise to methods that utilize posters, notices, safety bulletins, slide and motion pictures, etc.

It should also be pointed out that many of the approaches that are listed under a specific personal characteristic serve equally well when appealing to other characteristics. For example, it is probably true that the suggested approach to a person who is strongly motivated by a sense of responsibility would likewise appeal to the logically minded person, and vice versa.

Finally, attention is directed to the possibility of utilizing the thoughts given in this chapter in *reverse* form. This can be done by expressing the negative rather than the positive side in each case. In illustration, instead of featuring cooperation to the loyal employee, lack of cooperation can be expressed as disloyalty.

The characteristics listed herein are not necessarily all that may be appealed to in accident-prevention work. Other motivating characteristics and additional applications of them have been omitted. The effort is made to impress upon the minds of safety directors, supervisors, and foremen that the employees whom they control are human beings with emotions and ambitions that may readily be appealed to in furthering the work of accident prevention.

The characteristics by which men are motivated are many and complex, and the work of the true psychologist is undoubtedly most difficult. In the average case, however, and having safety only in mind, it is probably sufficient to make arbitrary use of any one or more of the common methods of appeal; such as self-preservation, reward, pride, etc., with the justifiable hope that satisfactory if not perfect results will be secured, and with the understanding, too, that if one method of appeal does not succeed another may be tried. However, where results are not secured by the arbitrary selection of a particular method of attack it is highly important that consideration be given to methods that appeal to predominating characteristics. Many a plan designed to create and maintain interest has failed utterly because it has been based on the plan of bonuses and prizes, whereas the employees were not interested in such things. Many a competitive no-accident contest has failed because employees did not care to strive with one another or with other departments or plants and because they resented having the good records of their competitors flaunted before them. Many an appeal to loyalty has failed because the employees were not fundamentally loyal. From many points of view it must be admitted that unless individuals are mentally or physically defective or abnormal it is probable that their interest can best be aroused and maintained by a means of approach that caters to a personal characteristic of a predominating nature. It is the opportunity and responsibility of the safety director, the supervisor, or the foreman to utilize to the best of his ability such knowledge of practical psychology as he possesses.

Creating and Maintaining the Interest of Management.—Although the primary purpose of this chapter is to deal with methods of creating and maintaining the interest of foremen and the employees whose work they direct, it is undoubtedly of interest to comment briefly on ways and means whereby *management* also may be induced to take an active interest in accident prevention.

The list of motivating personal characteristics given on page 73 is, of course, fully as applicable to employers as to employees. However the details of application are quite different. For example the approach to management cannot be the same as to employees for several good reasons, one being the absence of the same form of supervisory authority that management itself has when it deals with salaried and wage-earning employees. Another reason is that there is less opportunity to establish mutually satisfactory relations between management and the persons who attempt to influence management's attitude than exists between employees and employers.

The task of interesting management also differs from that of creating the interest of employees, because certain methods of appeal do not have the same force in one case as in the other. The general manager and the machine tender may have an equally keen sense of pride, yet the "no-accident" button which the machine tender cherishes as a token of his departmental safety record might not prove to be so much of an incentive in the case of the general manager. The latter would probably be far more proud of earning a lower insurance rate than his closest competitor. However, the fact remains that management and employees possess similar motivating personal characteristics and that these should be given consideration when approaching the task of creating and maintaining interest. Inasmuch as the individual characteristics have heretofore been listed, a few typical examples, applying wholly to management, follow:

Example 1.—Mechanization of industry, business depressions or booms, emergency situations, and labor troubles, fortunately do not entirely destroy the sense of humanitarianism that should be and still is an inherent quality of American businessmen.

The accident record of a large food-products plant had become increasingly worse over a period of years notwithstanding that tools and equipment were reasonably safe and that physical and personal conditions in general were above average.

The trouble was of the "underlying cause" nature. Specifically there was no coherently planned safety organization. This situation existed because the president of the organization, who had a dominating personality, strongly objected to "red tape" and clerical procedures and persisted in regarding organized safety work as nonessential paper work.

However, the president was even more strongly of a humane nature and had demonstrated this characteristic time and again. He contributed generously to local charities, had endowed a hospital, made personal deliveries of Christmas and Thanksgiving baskets, maintained a plant health and benefit association and had frequently granted leaves of absence with full pay to deserving employees.

The successful approach in his case can be summed up by the culminating statement of the engineer of the insurance carrier as follows:

"One executive order from you, Mr. President, is all that is required to make life happier for more than 100 of your employees and their wives and children. Without that order, these men will be injured, some of them seriously, in the next 12 months just as more than 100 men were injured during the past year."

In reply to the inquiry "What order do you refer to?" the engineer said:

"Order your general manager to place accident prevention immediately on an effective, practical and systematic basis, in accordance with the proposed plan that is already in his possession."

The suggestion was accepted, the order was issued. and the results fully met the engineer's expectation.

Example 2.—A men's clothing manufacturer became actively interested in safety when he was shown that his annual compensation insurance premium was more than 20 per cent greater than that paid by a local competitor and that the occurrence of preventable accidents was responsible.

An interesting feature of this case was the method of approach that was used by the plant safety engineer. This engineer knew that the manufacturer boasted of having a better plant than his rival, paying better wages, having more skillful employees, using higher grade materials and selling a better product at no greater cost to the purchaser.

The engineer therefore seized the first opportunity to show this employer that in one respect at least—the frequency and cost of accidents—his plant was not so good as that of his competitor.

Example 3.—The interest of the chief executive of another industrial manufacturing concern was aroused when the accident problem was presented in terms that were in common use with regard to sales, production, and overhead cost. The entire plant product was made, sold, and shipped *by the ton*. The "ton" was a unit of measure of cost that was applied to light, heat, power, taxes, and profit. The output of machines was on a tonnage basis. The number of employees required was estimated by the expected tonnage to be produced. Practically every form of cost and activity, except as related to insurance and accidents, was compared with tonnage of product.

This situation provided an interesting and useful approach to safety. A brief was prepared, therefore, in which the increasing frequency and also the cost of accidents was expressed as "so many accidents and so many dollars per ton." Violations of safe-practice rules likewise were compared with tons of product, and probable savings as a result of improved safety work were calculated on a similar basis. Incidentally the new unit of measurement led to the discovery that accidents were more expensive than several items of overhead cost that had consistently received far greater attention.

Example 4.—In an iron foundry the chief executive became interested in safety when the direct analogy between the causes of accidents and the causes of production faults was explained to him. In this plant excessive production cost had occurred because instructions that certain portions of the batch be *weighed* before placing it in the cupola were disregarded. Employees also disregarded instruction that ladles be heated and thoroughly dried before use. Thus quality and volume of production and also the plant safety record were affected by lack of control over the performance of employees. The practices in both instances could readily have been observed and corrected. When this analogy was made clear to the executive he became an enthusiastic convert to the idea that management has the ability, the opportunity, and the power to prevent accidents. He put his thoughts into practice with amazingly favorable results.

Example 5.—The interest of management in another case was created by proving that accident occurrence had a detrimental effect on the morale of the employees. In this plant management set great store on the maintenance of sympathetic and friendly relations with its employees. Long-term service was encouraged and rewarded by high wages, recognition of ability, and by granting an employee committee the privilege to participate in decisions that affected certain policies of the company. Group life insurance was provided on an attractive basis. Vacations with full pay were given, and in several other ways the lot of the worker was made agreeable.

Although the plant and its equipment was satisfactory as to guarding of machines and other mechanical hazards, the accident record nevertheless was regrettably high.

Specific careless and thoughtless acts of employees were responsible, and the management was loath to apply the obvious remedy because it feared that a more strict enforcement of rules would disturb morale.

In order that corrective action of the right kind could be initiated it was necessary to point out a number of instances such as follow:

A. The men in an entire department had to be sent home in the middle of the afternoon when they became "jittery" following the occurrence of a fatal accident in which an employee became caught in a revolving shaft pulley.

B. Employees who worked on assembling machines asked to be transferred to other work because of minor injuries to several members of their group.

C. Two girls fainted when they witnessed a freight elevator accident in which an employee raised a shaftway gate and attempted to board the ascending platform. Although no personal injury resulted, the shouting of the employee who slipped and hung precariously from the platform was alarming.

Thus management was convinced that accident occurrence seriously affected employee morale. Safe-practice rules were more strictly enforced with no unfavorable reaction, accident frequency decreased, and morale improved.

These five examples illustrate but a few of the many ways in which the interest of management may be aroused with regard to safety. Further exposition seems unnecessary for several reasons. One of these is that management in general is already interested. The expressed sentiment of many of the nation's highest business executives, federal and state public officials, the national, state, and municipal chambers of commerce, trade and labor organizations, technical societies and representative individual persons, is that accident prevention definitely is *good business.*

CHAPTER IV

FACT FINDING

Assuming that a sufficient degree of executive and employee interest has been created to support an attack upon the accident problem, the next major step is the development of such pertinent facts as are required to formulate practical effective procedures in accident prevention. These facts should relate not only to accidents that have already occurred but also to circumstances and conditions that have the probability of producing accidents. Thus, the sources of information lie in past accident history, the data obtained from inspection and survey, and the knowledge and imagination of informed persons.

Inasmuch as the facts of most value are those that relate directly to the direct and proximate *causes* of accidents, the first section in this chapter is devoted to the discussion and explanation of *accidents* and *accident causes*. Then follows an outline of pertinent facts, by kind; also illustrations and a description of methods of determining and recording the facts, together with comments concerning the selection of facts for use in taking corrective action.

Accident Types.—In Chap. II it is shown that an accident is but one of several factors in a chain of events that may terminate in a personal injury. Many definitions have been given for the word "accident." Dictionaries define it as "an unforeseen event." In this discussion we are not concerned with *any* event but with those particular events that may result in injury to persons. Further, in certain cases of industrial injury a true accident is not an unforeseen event. A person may know in advance that he will fall or be struck by an object, but unfortunately he cannot escape. For example, a railroad laborer may be caught in the frog of the tracks in front of an onrushing train. In a sense, the accident (struck by) will not be unforeseen as far as the immediate time factor is concerned. Moreover, it is only the event that *directly precedes and causes or may cause an injury* that constitutes the subject of this text. A better definition, one more suited to the viewpoint of safety, is given on page 15.

Events that conform to the definition of "accident" given in the text are listed here:

. . . . . .

TYPES OF ACCIDENTS

Striking against (refers generally to contacts with sharp or rough objects, resulting in cuts, slivers, punctures, etc., due to striking against, kneeling on or slipping on objects).

Struck by (falling, flying, sliding, or moving objects).

Caught in, on, or between.

Fall on same level.

Fall to different level.

Slip (not fall) *or overexertion* (resulting in strain, hernia, etc.)

Exposure to temperature extremes (resulting in burning, scalding, freezing, heat exhaustion, sunstroke, frostbite, etc.).

Inhalation, absorption, ingestion (asphyxiation, poisoning, drowning, etc., but excluding exposure to temperature extremes).

Contact with electrically charged objects (such as results in electrocution, shock, etc.).

Accident type, not otherwise classified.

CAUSES OF ACCIDENTS

The term "cause" needs no explanation inasmuch as it is used in the text exactly in accordance with its commonly accepted definition, namely, "that which occasions or effects a result." It is granted, however, that there may be several causes of any one accident. This makes it necessary, for clarity, to use the expression "*direct* or *proximate* cause." Applying these thoughts to accident prevention and keeping in mind that an accident is defined as a specific event, such as "struck by" or "fall," it can be concluded that the direct or proximate cause of an accident can be only that specific unsafe act of person or that mechanical or physical hazard that occasioned or effected the *striking* or *fall* and resultant injury of a person.[1]

The selected unsafe act or mechanical hazard, however, is only the first, direct, or proximate accident cause. In turn, there is a subcause of the *accident* which is synonymous with the direct cause of the *unsafe act* or *mechanical hazard*. Here again the illustration showing the row of dominoes is helpful. It will be

[1] See section entitled "The Accident Sequence," Chap. II.

seen from the illustration that a "fault of person" is the direct cause of the unsafe act or unsafe condition and that environmental or inheritable faults are the direct causes of "faults of persons."

All the factors in the chain of events culminating in accidental personal injury, therefore, are "causes." For example, environment causes faults of persons. These in turn cause unsafe acts of persons. The unsafe acts cause accidents, and the accidents cause injuries. To go a step further—one that it is not necessary to discuss in a text on *accident* prevention—it is clear that the injury also is a cause, inasmuch as injuries result in cost and suffering.

The term "cause" cannot be used loosely; to be of value it must be related to the condition or circumstance which it occasions or effects. In this text, except when otherwise expressly stated, the term "direct and proximate cause" is applied to the accident per se and means an unsafe personal act or an unsafe mechanical condition that results directly in an accident. The term "subcause" refers to the personal factor (specific fault of person) that occasioned, effected, or permitted the unsafe act or mechanical hazard. The term "underlying cause" refers to managerial and supervisory faults and to social and environmental conditions that are outside the work place.

Proximate Causes and Subcauses (Mechanical or Physical).—For practical purposes and as far as mechanical and physical causes are concerned, it is generally sufficient to know that a machine operator was injured on the cutting edge (point of operation) of a *wholly unguarded* machine. The proximate and direct cause is *unguarded point of operation.* Inasmuch as the method of preventing a similar accident is obvious and readily applied, the value of ascertaining indirect causes is slight, in cases where such mechanical or physical hazards exist. Nevertheless, there are such causes. The foreman may have failed to check and the superintendent may have failed to ask for such a check; the employer may not have approved the necessary expenditure for guards; the designer and builder could have erred; the education of the designer and builder may not have included design and building for safety. The attitudes, lack of knowledge, or other personal faults that permit or occasion these circumstances are subcauses of many accidents that are caused directly by mechanical hazards.

Expediency and practicability require that exhaustive treatment in this text, so far as it relates to mechanical or physical hazards, be confined to direct and proximate causes, with only sufficient explanation of indirect causes to assure recognition of their existence and to encourage use of them where either desired or necessary.

Unsafe Mechanical or Physical Conditions (Direct and Proximate Accident Causes).

Inadequately guarded.

Unguarded.

Defective condition (rough, sharp, slippery, decayed, corroded, frayed, cracked, etc.)

Unsafe design or construction.

Hazardous arrangement, process, etc. (piling, storage, aisle space, exits, layout, planning, overloading, misaligning).

Unsafe illumination (inadequate or unsuitable).

Unsafe ventilation (inadequate or improperly distributed).

Unsafe dress or apparel.

Proximate Causes and Subcauses (Personal).—In connection with the unsafe acts of persons (which are the direct causes of the majority of accidents) the immediately preceding subcauses are of great value in determining the most practical remedy. For example, it is not always enough to know merely that a machine operator *oiled his machine while it was in motion*. The reason why he acted unsafely is often of vital significance. He may have been required to do so by the foreman. Enforced time schedules may have prevented him from taking safer action. He may not have realized the danger, may have been physically or mentally unsuited, or may have willfully disregarded instructions. Thus, in the case of direct causes of a personal nature (unsafe acts of persons) more importance attaches to subcauses than in the case of mechanical or physical faults.

Unsafe Acts of Persons (Direct and Proximate Accident Causes).

Operating without authority, failure to secure or warn.

Operating or working at unsafe speed.

Making safety devices inoperative.

Using unsafe equipment, hands instead of equipment, or equipment unsafely.

Unsafe loading, placing, mixing, combining, etc.

Taking unsafe position or posture.

Working on moving or dangerous equipment.

Distracting, teasing, abusing, startling, etc.

Failure to use safe attire or personal protective devices.

Note.—The unsafe acts of persons listed above are merely general heads or categories under which more specific acts may be grouped. For the individual plant or industrial operation it is more informative to specify the particular unsafe act that is committed. For example, the general head "Making Safety Devices Inoperative" can be subitemized as:

1. Removing guards.
2. Tampering with adjustment of guard.

For further details with regard to specific unsafe practices, see the "Proposed American Recommended Practice for Compiling Industrial Accident Causes—Z16.2" as released by the American Standards Association.

Research indicates that the unsafe acts of persons are the direct and proximate causes of the majority of all industrial accidents. Not more than 2 per cent of all accidents are of the so-called "act of God" or wholly unpreventable type. Of the remaining 98 per cent, 50 per cent are practicably preventable and 48 per cent could be prevented if it were not for practical consideration of cost and interference with production and profit. All preventable accidents are controllable by management.

Reasons for Unsafe Acts (Accident Subcauses, Personal).—Attention is directed at this point to Chap. II where it will be noted that mechanical or physical hazards and unsafe acts of persons are caused by "faults of persons." It has already been explained that the reasons for the existence of mechanical hazards are not as generally required as are the reasons for unsafe acts. The following list, therefore, although applicable to mechanical hazards, is suggested for use chiefly in connection with unsafe acts of persons.

The list, as presented, shows the type of corrective action that is suggested by each individual personal subcause.

REASONS THAT PERMIT OR OCCASION THE UNSAFE ACTS OF PERSONS (MENTAL, BODILY, AND ENVIRONMENTAL CIRCUMSTANCES THAT EXIST TO AN EXTENT THAT CONSTITUTE FAULTS)

Reasons	Basis of Remedy
Improper Attitude	
1. Willful disregard of instructions....	Discipline, placing, and psychology.
2. Recklessness....................	Discipline, placing, and psychology.
3. Violent temper..................	Placing, psychology, medical treatment.
4. Absentmindedness................	Placing, psychology, medical treatment.
5. Willful intent to injure............	Discipline, placing, and psychology.
6. Nervous, excitable, etc............	Placing, psychology, medical treatment.
7. Failure to understand instructions..	Education.
Lack of Knowledge or Skill	
8. Unaware of safe practice	Education.
9. Unconvinced that practice is unsafe	Education.
10. Unpracticed or unskilled	Education.
Bodily Defects	
11. Defective eyesight	Placing and medical treatment.
12. Defective hearing................	Placing and medical treatment.
13. Muscular weakness	Placing and medical treatment.
14. Fatigue.........................	Placing and medical treatment.
15. Existing hernia..................	Placing and medical treatment.
16. Crippled........................	Placing and medical treatment.
17. Existing heart or other organic weakness.......................	Placing and medical treatment.
18. Intoxicated.....................	Discipline, psychology, and medical treatment.
Safe Practice Difficult or Impossible	
19. Circumstances prevent safe action..	Engineering revision.
20. Circumstances make safe action awkward or difficult.............	Engineering revision.

FACTS OF IDENTIFICATION

No substantiation is required for the statement that the facts of accident occurrence should include the identifying items listed here:

1. The time of injury (hour, day, month, and year).
2. The place (town, plant or place of work, department or specific location)

3. The person injured (name, number, shift, or crew).
4. The nature and severity of injury.
5. The witnesses and participants.
6. The kind of accident (fall of person, struck by, etc.).
7. The agency—meaning the machine, tool (also parts), process, substance or person that is most closely associated with the injury usually because of its hazardous condition or action.

COROLLARY FACTS OF CAUSATION

In addition to the foregoing identifying facts and the major facts of causation (the mechanical or physical hazard, the unsafe act, and the reason for the unsafe act), other data are often of value in determining the best practical remedy, as follows:

1. The age, experience, and the bodily and mental characteristics of the injured person.
2. The previous accident record of the injured person.
3. The outside or "home" environment of the injured person.
4. The foreman or supervisor and his supervisory abilities and procedures.
5. The operation or process involved in the accident.
6. The extent of lost time and the cost of the injury.
7. The existence of safe-practice rules covering the individual case.
8. The name of the attending physician or surgeon and the record of treatments.
9. The previous accident record of the machine or other agency, and the place and department of work where injury occurred.
10. Description and cost of property damage, or spoilage.

The foregoing corollary facts are of such nature that, if of interest, they would automatically be developed when the major facts of accident cause and those of an identifying nature are determined.

Stress has already been placed on the importance of certain kinds of accident-occurrence facts in the work of accident prevention. These are the facts that are grouped in the foregoing lists under the headings of first, direct, or proximate causes and personal subcauses. Space limitations prohibit elaboration of all facts, including those of a corollary and identifying nature. As a matter of course it is understood that a plant safety engineer, a director of safety, or any other person who assumes the direction of safety work, will obtain and record as necessary many factual items that are not of direct major interest from the viewpoint of prevention.

For example, the necessities of orderly clerical accounting require that the injured person be identified, that the time of the accident and of work stoppage be recorded, also the time when the injured person returns to work; and that the unfinished work of an injured person who is absent because of his injury be checked and assigned to another employee. Consequently, no particular change in existing procedures as to finding and recording these identifying and corollary accident facts is recommended. Such facts are valuable, but not always vital, in accident prevention; further, no special skills are required to ascertain them; and, finally, those most necessary are almost invariably recognized and used in current general practice.

UNDERLYING FACTS OF CAUSATION

Although underlying accident causes will not be discussed in detail in this book, it is nevertheless appropriate to describe them briefly in order to indicate the part they play in accident prevention and to provide illustrative examples.

The line of demarcation between first, direct, and proximate causes and those of an underlying nature, is similar to the distinction between employee and managerial responsibility. In other words, underlying accident causes are faults of management and supervision plus the unwise methods, attitudes, and procedures that management and supervision encourage or at least fail to correct.

There are also underlying causes of a social, environmental, and inheritable nature which, in this text, are merely alluded to. The reason for omitting detailed explanation is that it would require an exposition dealing with psychology, psychiatry, and pathology, social and governmental conditions, slum clearance, and other matters of less direct significance than the proximate causes that are discussed herein. Further, it is quite probable that at least a 50 per cent reduction in the existing frequency and severity rates of industrial accidents may be brought about without delving into such causes, except from a layman's point of view. Finally, the exclusion of detailed treatment is well justified because *industry in general is not fully conversant* with the more simple and direct approach to accident prevention and *does not apply it in practice*. These reasons for restricting the scope of this text with regard to such indirect causes apply to some extent to underlying managerial and supervisory attitudes and procedures as well. In this case, however, it may also be said that such conditions are the same when they result in accidents as when they result in poor quality or volume of production for which methods of control are well known to management.

The underlying managerial and supervisory causes of accidents are best described in narrative form. Management may be uninformed as to the value and practicability of accident prevention, or it may be unacquainted with factual methods of approach. In addition, it may have a wholly improper attitude toward recognition of its moral responsibility for the maintenance of safe mechanical environment and the safe performance of employees and for accidents arising from these causes. Management may be handicapped further by lack of funds necessary for plant safeguarding.

The supervisory staff of a given plant may be inadequate, poorly informed, incapable, or of improper attitude. The underlying accident causes in management and supervision, such as described, can and often do occasion or permit the existence of improper methods and procedures, these in turn being followed by direct and proximate accident causes.

Where such faults exist it is frequently difficult to effect the desired results in controlling accident occurrence by methods that do not take them into account. Therefore, if the accident problem does not yield to the more direct approach, as herein advocated, it is advisable to dig a bit deeper in the work of fact finding. In the following list are given a few typical examples of conditions occasioned or permitted by managerial and supervisory fault:

TYPICAL EXAMPLES OF CONDITIONS OCCASIONED OR PERMITTED BY MANAGERIAL AND SUPERVISORY FAULT

1. Lack of organized safety procedures, including plant safety inspector, committees, accident investigation, forms, etc.
2. Inadequate or ineffective safety work.
3. Lack of executive direction of and participation in safety work.
4. Failure to guard machines and to provide adequate light, ventilation, first-aid hospital and sanitary facilities, personal protection, safe tools, and safe working environment in general.
5. Lack of suitable procedures for examining new employees for physical fitness and work experience.
6. Lack of suitable procedures for assignment of employees to work that they can do safely.

7. Poor morale of employees.
8. Lack of suitable training and instruction of employees in safety.
9. Lack of enforcement of safe-practice rules.
10. Failure to place responsibility for accident occurrence.

Examples showing how the recognition of underlying causes and of the conditions that they occasion or permit may be utilized in the selection of remedial action that is directed to the correction of the more direct causes are given in Chap. V.

METHODS OF FINDING ACCIDENT FACTS

The person who should be best qualified to find the more important facts of accident occurrence is the individual, usually the supervisor or foreman, who is in direct charge of the injured person. This individual is not only best qualified but has the best opportunity as well. Moreover, he should be personally interested in events that result in the injury of workers under his control. In addition, he is the man upon whom management must rely to interpret and enforce such corrective measures as are devised to prevent other similar accidents. The foreman, therefore, from every point of view, is the person who should find the major facts (proximate causes and subcauses) of accident occurrence.

Three fields of activity should be used in developing accident facts:

First.—Analysis of past accidents.

Second.—Inspection and observation of existing conditions.

Third.—Judgment and experience.

JOB ANALYSIS

In the application of the principles of accident prevention it is sometimes found that difficulty is experienced in correcting unsafe practices, chiefly because employees are inherently unsuited to the work that they are obliged to perform. Chapter VIII treats of the failings and characteristics of employees, ways and means to find them by psychological analysis of underlying causes, and how to overcome them. There is another way to attack the situation, however, and that is to analyze the job and then, accepting employees as they are, select the man best fitted to the peculiarities of the work. Job safety analysis, in other words,

JOB ANALYSIS

PRODUCTION DEPARTMENTS

DEPARTMENT *82S* **MILL** *8* **NAME OF JOB** *Spinning & Doffing*
(See Remarks for details)

NATURE OF WORK

Heavy	Standing #	Bending #	Slow	Clean #	Floor	Sweeping
Medium #	Sitting	Pulling	Quick #	Dirty	Machine #	Cleaning
Light	Walking	Pushing	Varied	Dusty	Bench	Oiling
		Lifting #	Routine #	Oily		
		Reaching #	Hazard	Wet		
				Odorous		8

NAME OF MACHINE

Hammer	Bale Breaker	Softener	Breaker	Finisher	Drawing Fr.	Roving Fr.
Spinning Fr. #	Winding Fr.	Twisting Fr.	Gill Spinn.	Skein Winder	Doubler	Cop Winder
Tuber	Layer	Polisher	Single Baller	Multi Baller	Coiler	Reeler
Hanker	Shaper	Rope	Small Press	Roller	Patch Cutter	Sewing
Loom	Starch Mixer	Filling Winder	Slasher	Emul. Mixer	Dryer	Extractor
Line Breaker	Line Spreader	Line Drawing	Finish Drawing	Bale Press	Roller	Patch Cutter
Elevator	Electric Truck	Lathe	Scale			

REQUIREMENTS

Preferred Age Height *Min. 5'-2"* Weight Physical Rating *C* Sex *Male or Female*

Time required to learn job *One month* Day Work Piece Work #

When piece work *after one month*

Training and experience *necessary, except for learner*

Read English* Write English Count Weigh Mark

Remarks* *See next page*

Approved, General Supt. Mill Supt. Foreman

Service Department Date

(over)

FIG. 7—Job analysis report form. (*Courtesy of Ludlow Manufacturing Associates.*)

Remarks Continued

Must be able to distinguish symbols. Eyesight must be good, not color blind; feet should be in good condition and there should be no deformities of either hand. The spinner when putting up rove must stretch a maximum reach of 6'-0". Most of the doffing is done from a builder rail which necessitates bending to within 15" of the floor. The spinner must keep up rove, piece ends without making slubs, and keep the front of the frame clean. About 25 % of time she may sit idle. Accidents may occur when piecing an end. The spinner must be taught to avoid flyers.

Considerable dexterity which can be acquired only by experience is required to piece ends. Almost certainly a learner will receive small scratches, bruises, and blisters on the hands or fingers. The foreman must watch these learners and insist that all injuries, however frequent or seemingly slight, must be reported to the first aid room for treatment.

A spinner should clean only the front of the machine when it is running. Gear cages should not be opened by anyone while a spinning frame is running. Violation of the rule regarding opening gear cages should result in layoff and may result in discharge. All safety rule violations must be reported to the safety engineer.

Sometimes bobbins become splintered. Train the spinner to set such bobbins aside for the attention of the foreman. If used they may cause sliver accidents and spoil yarn.

Boxes lined with wood become splintered. Train the spinner to mark such boxes for the attention of the overseer. When they are sent to the carpenter shop for repairs they may be lined with fibre board. Sliver accidents arise out of the use of splintered boxes.

Train spinners to use four inch snips. Never allow them to use a knife or a sharp-pointed scissors.

Never allow spinners to put mirrors up near the machine frames or on the frames. Accidents will surely occur if this practice is allowed. Wraps, extra clothes, shoes, combs, etc., must be kept in the lockers and must be used in the dressing room or wash room—never at the machine.

Teach spinners never to push a bobbin truck out into an aisle without first looking to see if it can be done safely.

Advise spinners against wearing high heeled shoes and enforce the rule against the use of felt slippers.

Make sure that the belt man does not leave short pieces of belt dressing where a spinner may get hold of them. She may be tempted to try to remedy a slipping belt and be injured in the attempt. This practice is forbidden but it should be made impossible.

Some spinners are high steppers. If a girl appears to be tired in the morning find out if she has had breakfast. If she has not, insist that she get something to eat immediately or go home. Many of the falls that spinners suffer are caused from weakness induced by lack of morning meals. Some may be too tired to work because of lack of sleep from too much dancing the night before. Don't permit girls to work who drop off to sleep every time they sit for a minute. Send them home to rest.

FIG. 8.—Reverse side of job analysis report form. (*Courtesy of Ludlow Manufacturing Associates.*)

has a place in accident prevention. Such analysis of a given job will show whether the work is heavy or light, whether it requires strength, skill, quickness of hand or eye, judgment of distance, or all combined. It will indicate whether previous experience or training is required, whether a correct sense of color, hearing, or smell is necessary, and any other special physical or mental qualities. In addition, it will break the job down into its several operations and show the specific hazards of each so that the latter may be recognized in advance and made known to the employee, and so that he may be fully instructed in avoiding them. An example of job analysis typical of the method here outlined is given in Figs. 7 and 8.

ANALYSIS OF PAST ACCIDENTS

When an accident and its resultant injury have occurred, the event becomes a matter of history. Singly or in groups the history of these past accidents provides a fertile field for fact finding. If the work of investigation and record keeping has been done well, each past accident will already have been analyzed and its facts recorded in such manner that further analysis covering a considerable period of wide exposure will require merely the *assembling of facts* already available.

Supervisor's Report of Accident Investigation.—The accident investigation report form, prepared preferably by the supervisor, is the basic unit of all accident-cause data. There is little value in suggesting any one complete accident investigation form, inasmuch as the particular information desired, aside, of course, from the pertinent and major facts of accident causation, varies widely with specific cases. It is sufficient to say that whatever the form may be, it should invariably include: (1) the facts of identification, such as given on pages 107–108 in this chapter; (2) the major facts of causation, namely, the unguarded machine or other mechanical or physical hazard, the unsafe act of a person, and the probable reason for its commission; and (3) the facts as to prevention, namely, what was done and what should be done to prevent the occurrence of other similar accidents. On the sample form of this kind shown in Fig. 9 on page 115 many of the usual questions that do not relate directly to causal factors have purposely been omitted because they are not pertinent to this discussion.

Accident Analysis Master Sheets and Work Sheets.—When information concerning each individual accident is recorded on a separate supervisor's report of accident investigation, the analysis of mass data is facilitated. In the case of large organizations, the punch-card method of recording is feasible, thus providing a ready means of drawing off totals, by kind.

In smaller concerns where punch cards are not used, a simple manual procedure is practicable. All accident-investigation

SUPERVISOR'S REPORT OF ACCIDENT INVESTIGATION

Insert questions of identification; such as—company, department, or subsidiary, location, time of accident, date of investigation, name of injured person, age, kind and severity of injury, treatment, doctor, witnesses.

A. How did the accident happen?..............................

....

(Describe the accident fully, stating whether the injured person fell or was struck, etc., and all the factors contributing to the accident. Use other side of report for additional space.)

B. What machine, tool, substance, or object was most closely connected with the accident?..............................

....

(Name the machine, tool, appliance, gas, liquid, etc., involved)

C. If machine or vehicle, what part of it?..............................

(State if gears, pulley, motor, etc.)

D. In what way was the machine, tool, object, or substance defective?.

....

E. Were mechanical guards or other necessary safeguards (such as goggles) provided?..............................

F. Was the injured using them when accident occurred?..............

G. Name the unsafe practice of the injured person or other person that resulted in this accident..............................

....

(Describe as lifted with bent back, refused to wear goggles, removed guard, ran down stairs, etc.)

H. Why did the person act unsafely?..............................

I. How can you prevent accidents of this type?..................

....

(Specify the remedial measure, such as: better illumination, better ventilation, providing goggles, providing a better guard, enforcing instruction, training employees, etc.)

J. What have you already done to prevent a similar accident?........

....

....

(Signature of Supervisor)

Note: No attempt is made in preparing this sample to illustrate a "ready to use" form. The detail as to arrangement and questions other than those relating directly to accident cause must vary according to individual circumstances.

FIG. 9.

reports are assembled for the particular department, operation, division, or plant to be analyzed. For convenience, the data from the individual reports may be listed in chronological sequence on master sheets as shown in Fig. 10. Work sheets are then prepared for convenience in drawing off comparable and contrasting data, preparatory to the selection of major conclusions.

The sample work sheets shown herein[1] are designed to facilitate the comparison of any two of the several kinds of accident facts. A single printed form may be used for all combinations of facts, if the headings are left blank and filled in as required. The individual analyst who deals with data that are too voluminous for mental calculation will, of course, first want to know the common and elemental facts of identification. He will probably select as the first two heads (1) department or foreman and, (2) kind of accident or injury. From a comparison merely of these two kinds of facts he can "locate" his accidents and be able to find *where* the greatest number of certain kinds of accident occur. As has already been pointed out, "location" is not an accident-cause factor. However, this information is valuable and, in fact, quite necessary. Next, the analyst will probably select any two other kinds of information in which he is interested, perhaps because of a preliminary rough study. If he has been impressed by the frequency of accidents on certain machines, he will select the two heads—agency (including a specific list of machines) and kind of accident or kind of injury. He may then proceed to compare agency with unsafe act, mechanical hazards with agency, reason for the unsafe act with the unsafe act itself, or any other combinations that may be of value. He may choose also to select heads that are not featured herein, such as name of injured person, time of day, day of month, kind of work, length of service, age, etc.

The work-sheet analysis described, permits worth-while conclusions to be drawn concerning accident causes. In particular, it leads to the discovery of personal or mechanical hazards that *predominate* and should therefore be given first attention. This is the kind of preliminary consideration of accident occurrence data that should invariably precede the selection and the application of corrective practice.

Accident Summary Sheets.—The concerns that do not make use of tabulating machines will often find it advantageous to

[1] See Figs. 11, 12, and 13.

ACCIDENT RECORD
(Master Sheet)

Period covered.....................
From To

Name..............................Location....................
(State name of firm, also specific branch, subsidiary, or division to which this record applies)
(State specific location to which this record applies)

By whom prepared......................Date....................
(When submitted)

Name of injured person	Date of acci-dent	Depart-ment or foreman	Nature of injury	Kind of acci-dent	Unsafe act	Reason for act	Agency and part	Mechan-ical hazard
John Smith	2-1-42	Assembly	Shin bruise	Fall	Running downstairs	Reckless	Stairs steps	Worn nosing
Henry Hayes	2-4-42	Snagging	Foreign material in eye	Struck by	Not wearing goggles	Not sold on safety	Chisel	Burred

Note: The arrangement as to spacing, etc., of this sample form may not be suitable for an individual plant or operation. It is intended to serve as a guide to the preparation of a more convenient form, as local circumstances require. Primarily it illustrates one way in which the major facts of accident occurrence, taken from the individual reports of accident investigation may be listed in chronological sequence on a master sheet preparatory to mass analysis.

FIG. 10.

ACCIDENT RECORD
(Work Sheet)

Period covered.....................

From To

Name.................................Location..................

(State name of firm, also specific branch, subsidiary, or division to which this record applies)

(State specific location to which this record applies)

By whom prepared........................Date..................

(When submitted)

Kind of Accident / Agency	Striking against	Struck by	Caught in, on, or between	Fall on same level	Fall to different level	Slip (not fall) or over-exertion	Contact with temperature extremes	Inhalation, absorption, ingestion	Contact with electric current	Miscellaneous	Totals
Machines											
Elevators											
Hoisting apparatus and conveyors											
Pumps and prime movers											
Vehicles											
Electric apparatus											
Hand tools											
Boiler and pressure vessels											
Miscellaneous											
Totals											

Note: **For practical use, a form such as this one, and Figs. 12 and 13, should be left blank except for the title and the items above the double line. This will permit the user to insert the desired particular headings in the vertical and horizontal spaces as here illustrated.**

FIG. 11.

ACCIDENT RECORD
(Work Sheet)

Period covered.................
From To

Name.................................Location...................
(State name of firm, also specific branch, subsidiary, or division to which this record applies)
(State specific location to which this record applies)

By whom prepared.......................Date...................
(When submitted)

Unsafe acts / Agency	Operating without authority, not warning others	Operating or working at unsafe speed	Making safety devices inoperative	Using unsafe equipment	Unsafe loading, placing, mixing, combining, etc.	Taking unsafe position or posture	Working on moving or dangerous equipment	Distracting, teasing, abusing, startling, etc.	Failure to use safe attire or personal protective devices	Miscellaneous	Total
Machines											
Elevators											
Hoisting apparatus and conveyors											
Pumps and prime movers											
Vehicles											
Electric apparatus											
Hand tools											
Boiler and pressure vessels											
Miscellaneous											
Totals											

FIG. 12.

ACCIDENT RECORD
(Work Sheet)

Period covered.................
From To

Name..................................Location...................
(State name of firm, also specific branch, subsidiary, or division to which this record applies)
(State specific location to which this record applies)

By whom prepared...........................Date.....................
(When submitted)

Agency \ Unsafe mechanical or physical condition	Improperly guarded agencies	Defects of agencies	Hazardous arrangement, procedure, etc., in, on, or around the agency	Improper illumination	Improper ventilation	Unsafe dress or apparel	Miscellaneous	Total
Machines								
Elevators								
Hoisting apparatus and conveyors								
Pumps and prime movers								
Vehicles								
Electric apparatus								
Hand tools								
Boiler and pressure vessels								
Miscellaneous								
Totals								

FIG. 13.

prepare an accident summary sheet on which complete usable accident data may be recorded. This form differs from the previously described work sheets and other forms primarily because it includes *all* pertinent data for each accident and provides for grouping or lumping all similar facts. Necessarily, it is a long and detailed form. However, in practical use it may be greatly simplified and lends itself well to manual coding methods.

As will be observed in Fig. 14, the left-hand vertical column shows the agencies (machines, tools, etc.) involved in the accident, whereas the horizontally arranged headings identify the department or foreman, kind of injury, kind of accident, proximate and subcauses, etc.

An individual plant, department, or other unit of industrial operation may not have a great variety of machines or other agencies. In other cases accidents are not of troublesome frequency on *all* agencies. Therefore, the list of agencies selected for recording may be reduced to only those in which there is chief interest, reserving under *X* miscellaneous the opportunity to record all others.

The same reasoning and opportunity for simplification applies also to all other headings. The heading "Unsafe Act" provides a good illustration. Although there are not more than 10 general groupings of unsafe acts of persons, as shown in the list of direct and proximate accident causes (personal), there are innumerable specific unsafe acts. Few of them, however, are at the same time of equal and important significance in any one unit of industrial operation. These few, plus provision for recording all others under an *X* miscellaneous heading, may be specifically listed, with a defensible expectation of obtaining data of value. The summary sheet, therefore, as revised and adapted to the situation in a given case, may be expanded or contracted, specific headings or items may be added or omitted, and any other suitable variations may be made to fit the form to the case. The particular form shown in Fig. 14 is merely for illustrative purposes.

Another opportunity for simplification consists in the use of symbols. A code can easily be devised, as is shown somewhat crudely in Fig. 14. The agency (circular saw) in the first entry, is identified as *A*. Therefore, if *A* or some other symbol is used to identify a particular agency such as a circular saw, it is

ACCIDENT

NAME ______________________________
(State Name of Firm, also Specific Branch, Subsidiary or Division to which this record applies)

BY WHOM PREPARED ______________________________

CAUSE AND

AGENCY	Dept., Foreman or Operation					Kind of Injury					Part of Body					Kind of Accident					Month of Acc.				
	1.	2.	3.	4.	X.	1.	2.	3.	4.	X.	1.	2.	3.	4.	X.	1.	2.	3.	4.	X.	1.	2.	3.	4.	X.
Machines																									
A. *Circular Saw*	/	//	/	/			///	//			~~////~~					////		/			/	//	/	/	
B. *Jointer*	/		//				/	//			//	/				//	/				//	/			
C.																									
D.																									
E.																									
F.																									
G.																									
H.																									
X.																									
Pumps and Prime Movers																									
A.																									
B.																									
C.																									
X.																									
Elevators																									
A.																									
B.																									
X.																									
Hoisting Apparatus and Conveyors																									
A.																									
B.																									
X.																									
Boilers and Pressure Vessels																									
A.																									
B.																									
X.																									
Vehicles																									
A.																									
B.																									
X.																									
Animals																									
A.																									
B.																									
X.																									
Power Transmission Apparatus																									
A.																									
B.																									
C.																									
X.																									
Electric Apparatus																									
A.																									
B.																									
C.																									
X.																									
Hand Tools																									
A.																									
B.																									
X.																									
Miscellaneous																									
TOTALS																									

FIG. 14.

SUMMARY

LOCATION ______________________
(State Specific Location to which this record applies)

PERIOD COVERED ________ ________
From To

DATE ______________________
(When Submitted)

IDENTIFICATION

Day of Acc.					Hour of Acc.					Mechanical Hazard					Unsafe Act					Reason for Unsafe Act					Part of Agency					No. of Accs.
1.	2.	3.	4.	X.	1.	2.	3.	4.	X.	1.	2.	3.	4.	X.	1.	2.	3.	4.	X.	1.	2.	3.	4.	X.	1.	2.	3.	4.	X.	
///	//				/	//	/	/		//		///			///			//			~~////~~				~~////~~					5
	/	/	/		/	/	/					///			///					/	//				///					3

Fig. 14.—(*Continued*).

unnecessary to write in the name of the agency itself as has been done in the cut. The check marks indicate the particular horizontal headings that apply to the accidents charged against this agency. The subdivisions of the horizontal headings can be identified by code symbols. The code letters or numbers correspond to a master list of symbols. The totals at the bottom of each column, also those opposite each agency, direct attention to the agencies, places, time, and causes of most accidents and to the kind of injury that results.

Use of Accident Facts in Selection of Remedy.—The creation and maintenance of executive and employee interest and of the will to achieve, the adoption of proper methods of analysis for determination of cause, and the development of causal facts would all be of little avail in accident prevention if the correct remedy were not selected, or if when selected it were not effectively applied. It is necessary, therefore, when the pertinent facts of accident occurrence have been determined, to make use of those that are of most importance, by drawing conclusions as to conditions and circumstances that are in need of first attention and as to practical methods whereby corrective action can be taken. There is little need to outline definite means of fact utilization, inasmuch as values are self-evident. In brief, however, the most effective procedures are listed hereunder in step-by-step order:

GROUPING WITHOUT REGARD TO CAUSE

1. Group accidents by:
   - Plant
   - Department or operation
   - Name of foreman
   - Type of accident
   - Nature and severity of injury
   - Day of month and time of day
   - Agency and part of agency
   - Age, sex, experience, and length of employment of worker
   - Miscellaneous identifying and corollary facts

GROUPING FOR CAUSAL FACTS

2. Group accidents by:
   - Unsafe act
   - Reason for unsafe act
   - Mechanical or physical hazard
   - Underlying causes (managerial and supervisory)

SELECTION OF PLACE OF ATTACK

3. Select place or location according to:
   Highest frequency and severity
   Highest frequency alone
   Highest severity alone
4. Choice of what to attack:
   Places or locations where accident concentrations occur
   Places or locations next in importance
   Predominating unsafe acts and mechanical hazards
   Predominating agencies
   Predominating accident types and injury types
5. Select direct remedy:
   Reversal of direct and proximate causes and subcauses (mechanical hazards, unsafe acts, and reasons for unsafe acts)
   Issue and enforce orders for corrective action
6. Select basic remedy (if direct remedy will be ineffective):
   Correction of managerial and supervisory faults

Reversal of True Accident Cause Indicates Remedy.—The methods advocated herein are based on fundamentals or principles of a correlated nature. One step leads definitely and logically to the next and assists in its handling. Cause-analysis and cause data of themselves, although interesting and of great value from a statistical viewpoint, are nevertheless defensible only as they assist in practical accident-prevention work. The causes given in this chapter are of this kind. In each case, simple reversal of a true cause points to a cure.

If an employee indulges in an unsafe practice (the direct cause of the accident) because he is unaware of safer methods (the subcause of the accident) and as a result suffers an accidental injury, the reversal of the direct and the subcauses indicates that he should be *instructed* in the *safe* practice of which he was unaware. Further, because a true cause may be ascertained only by analysis of known conditions and practices, the remedy, is *specifically* known. Cause-analysis, therefore, reveals not only the fault but also the correct remedy.

The questions are sometimes asked: Why analyze for cause at all if knowledge of the remedy is all that is required, and if it can be found in some other way? Why need any preliminary steps be taken? Why not proceed, without analyses, and apply such simple remedies as instruction, enforcement of instruction, education, and guarding of machinery?

There are excellent answers to these questions. In the first place, cause-analysis, at least as a mental procedure, is absolutely indispensable as a prior step in determining a remedy because, as has already been explained, a remedy is effective only when it is applied to a *particular* known cause of accidents. To be sure, the argument holds good that either the remedy or the cause alone is sufficient, if, as has already been stated, the one is the reverse or the opposite of the other. The point is, however, that without cause-analysis neither the cause nor the remedy is definitely known. Stated in another way, it may be said that three things must invariably be done if accidents are to be prevented: (1) The unsafe practices or conditions producing accidents and injuries must be determined—this shows the specific hazards to attack. (2) The causes of the unsafe acts must be determined—this shows the method of attack, as, for example, by education or instruction, discipline, placement, medical aid, etc. (3) Corrective action must be taken.

Value of Finding Accident Causes before Selecting Remedy.—Further, particularly when considering large groups of accidents wherein there is little similarity of type, it is highly important to record the causes before selecting a cure, since the cause and the remedy may be alike for a number of accidents which, from the point of view of type alone, are dissimilar and seemingly difficult to prevent.

A case in point is that of a cotton-spinning-and-weaving plant where a high accident frequency presented a troublesome condition. Girls received slivers in their fingers and hands from handling spools; other employees slipped on floors; still others were hurt on carding machines and pickers or while carrying sheath knives. There was no general run or trend of accident types. Even when several accidents of apparently the same kind did occur, investigation showed that the manner of occurrence varied. Cause-analysis provided immediate relief. It indicated that the same fault, as expressed in terms of cause and subcauses, was an underlying factor in over 75 per cent of all the accidents, notwithstanding that these accidents were of different types.

Sliver injuries occurred, for example, because instructions as to inspection, removal, and replacement of defective spools were willfully disregarded. Likewise, there were slips and falls because instructions with regard to limiting the area of floor to be wet down at any one time were not followed. Disregard of instruction also caused accidents on carding machines where employees, contrary to rules, made the card-cover locks inoperative; and it was a factor, as well, in the injuries on pickers and from the use of knives.

Thus, cause-analysis uncovered a predominant fault is supervision and an effective and definite place and method of attack.

Situations of the kind just described are the ones that present a most mystifying appearance to the safety engineer and that prove most difficult to solve—until he tries true cause-analysis.

In a rubber-tire manufacturing plant, notwithstanding a frequency of several thousand accidents annually, there seemed to be no target type of accident or of injury. One man would be hurt while handling a pipe wrench, another while using a pair of shears. In other departments one man would collide with a fixed object while another would be struck by a moving conveyor. Other employees slipped and fell or were struck by flying objects or were hurt by falling material. A bewildering maze existed, and the selection of a practicable remedy was difficult, until here, again, analysis and the recording of true causes pointed clearly to congestion of working space (direct mechanical or physical cause) as the cause of more than 60 per cent of all accidents.

It is necessary only to emphasize the fact, therefore, that selection of a remedy without cause-analysis is difficult and can be attained only by guess or instinct, both of which may be unreliable.

Selecting Predominant Causes for Attack.—There is no need to point out that the most important faults should be attacked first, but it may be in order to substantiate the bare assertion. No effort that is spread over too great an area can be effective. For this reason, predominant causes—those that result in a high frequency of accidents, coupled with actual or probable high severity—should receive first attention. It is generally agreed that man-failure accidents can be prevented by education of employees. This, however, is a thinly spread remedy and lacks virtue because of its too broad and general scope, its ambiguity, and its circuitous approach. By educating all employees with regard to safety, the accident-prone man is reached, also the chance taker and the man who disregards instruction, but these men receive no more attention than is given to the conscientious safe performer. Further, if the form of education is general, the employee is left to decide his own future course of action, unassisted by knowledge of what specific condition or practice to avoid and how to avoid it.

Of necessity, therefore, accident prevention must be more specific and more concentrated—it should not only specify just what particular kind of man failure or mechanical hazard exists but should also select as a first place of attack a cause that is of pressing importance as indicated by its prevalence or by the degree of probability that it will lead to a high frequency or severity of injury or both.

It is seldom, if ever, advantageous to attempt the prevention of all types of accident from all causes at one and the same time. Even in a small plant or in one that has a low accident frequency or, in rare cases, in a plant where true cause-analysis reveals that no one cause predominates and where all causes have equal significance, it is inadvisable to attempt the immediate correction of more than a few causes at one time. In this respect, accident prevention again may be compared with other phases of business activity. When the red "rush" tag for important correspondence, for example, is clipped on all correspondence, it immediately loses its value.

Examples Showing Similarity of Subcauses in Different Industries.—A New England granite quarry, having employed the cause-analysis method, found its remedy to lie in an attack upon willful disregard of instruction (subcause—personal) as related to a few specific unsafe practices (direct cause—personal):

Employees stood under suspended loads.

Others failed to get out of the zone of danger when blocks of stone were being hauled to the cars and hoists.

Men were in the habit of spalling rock, with little regard for the safety of other workmen who might be in line with flying pieces.

Debris was not kept cleared back from the outer edges of the working levels.

Frayed cable was used for guys and hoist cables.

Disregard of instruction is one of the most important of the supervisory or moral subcauses of accidents in all industrial operations. In a Pennsylvania coal mine the following unsafe acts were so caused:

Jumping on and off moving trips.
Riding front end of cars instead of in empties.
Standing between bumpers while coupling cars.
Failing to sprag standing cars properly.
Pushing cars by hand with hands on top of coal or on corners where clearance was small.

The accident troubles of a small bakeshop in New England likewise were found to result from disregard of instruction:

Cutting dough out of mixers without waiting for revolving paddles to slow down.
Cleaning dough mixer while paddles were revolving.
Lifting sacks and barrels of flour with back in a bent position.
Cleaning rolls of dough brakes from the inrunning side.
Piling of barrels and boxes too high.

Construction work in the erection of steel-frame skyscrapers is subject to identical procedure in accident prevention. Disregard of instruction resulting in the following unsafe acts, produced 55 per cent of all accidental injuries to employees during the erection of a 40-story building in New York State:

Riding material hoists.
Riding crane loads.
Laying tools on girders.
Walking across narrow partially suspended beams.
Throwing boards and other debris on walks and stairways.
Removing protective barriers from hoistways.

Small-dwelling erection is no exception to the principle that the selection of a remedy for accident occurrence invariably depends upon true cause-analysis. A certain contractor employed more than 1,000 men, practically all of whom were carpenters and bricklayers. Not more than 15 or 20 of them worked on the same job at the same time. The several operations produced a high accident frequency caused by disregard of instruction to comply with safe-practice rules, as follows:

Throwing concrete form boards with protruding nails in working spaces.

Failure to clean up premises.

Use of ladders that were too short.

Failure to shore trenches.

Standing on insecure working platforms.

Steel-rolling mills often develop the major personal subcause, willful disregard of instruction, as shown by the following examples of unsafe acts, obtained by cause-analysis:

Failure to stand clear as crane loads are picked up.

Crane men climbing up columns instead of using permanent ladders.

Crane men walking on girders instead of on catwalk.

Improper balancing of loads.

Employees walking across tables containing rolls, in front of mills, instead of using runways.

Men working in pairs while chipping billets, working face to face.

Climbing over and between railroad cars—jumping on and off rapidly moving trains.

The above examples are cited to show that although the extent and the nature of industrial operations must affect the type, severity, and frequency of accidents, the problem of prevention may be solved by applying the same scientific principles in each case. In fact, the direct and subcause of the accidents may be the same in many lines of work. In each of the foregoing cases willful disregard of instruction was a common factor, resulting in unsafe practice, accidents, and injuries.

The student of accident prevention who has read this chapter on fact finding carefully may ask: "Why select the subcause, disregard of instruction, for the conditions named as such in the foregoing examples; why not poor judgment, or chance taking?"

The answer is that the subcause named in these examples stood the test of reversal to provide a remedy.

In each of the cases referred to, the foreman had repeatedly issued instructions, and was making every reasonable effort to enforce them. The employees did not lack judgment; they realized that a certain amount of danger existed, yet they violated rules. They were not sufficiently impressed with the necessity for following the instructions for safe procedure, but primarily they indulged willfully in practices that were commonly known to be improper and unsafe. Instead of having the foremen issue more instructions only to have them disregarded, instead of taking the long-way-round path that lies in educating the individual employees to the point where they will refrain from taking chances, it was found highly and immediately effective to select a remedy that was based on the knowledge that disregard of instruction was a willful action.

Under other circumstances these same practices might well be charged to "unaware of safe practice," as, for example, when the foreman failed to instruct untrained employees in the safe methods of doing their work.

Incidentally, when disregard of instruction or some other definite subcause has been established conclusively as the reason for specific unsafe acts and has been further defined by illustrations of unsafe practices and conditions such as are given in the foregoing examples, the problem of accident prevention is a simple one indeed. No executive, once having determined that accident prevention is good business and having decided to take definite remedial action, would be greatly in doubt as to subsequent procedure, provided such facts as the above were available. Admittedly, accident prevention is a simple matter, but this is true only when it is conducted in accordance with principles similar to those here described, which will produce valuable and specific facts.

If, as shown by the steel-rolling-mill record, a high frequency of injuries exists because the employees willfully disregard instructions of the foremen and stand in the danger zone while crane loads are being picked up, the obvious remedy is to have the practice modified by the use of ordinary executive enforcement methods—first, by the foreman. and second, by his superiors.

Bear in mind, however, that this simplicity of procedure is possible only when proper cause-analysis has been made. Specific unsafe practices must first be established, by analysis, as a predominant cause of accidents, and the subcause, "willful disregard of instruction," or some other reason for the unsafe act, must be found before enforcement of instruction can be relied upon as a practicable remedy.

Incorrect analysis would have failed in all the instances cited. It would have led to no such clarity of conditions and would have produced no appreciable success. Referring to the steel mill again, prior to true cause-analysis and with regard to the accidents that happened when crane loads were being lifted, it was known only that employees were injured by falling objects, that they were hurt while engaged in moving or hoisting or handling material, or that a crane load slipped, etc. This directed attention merely to better methods of securing loads, warnings to cranemen, inspection of slings and chains, and other activities that were undoubtedly good procedure but did not correct the real condition that was chiefly at fault, namely, that men disregarded instruction to stand clear of the load when the crane took hold.

Again the question might be asked: Why bother with cause-analysis at all? These unsafe practices are obviously visible and improper and should be corrected. Why not merely set up the procedure of looking for them and correcting them, instead of adopting other apparently more complex methods? The answer is just as clearly stated as the question, and may be expressed as follows:

These unsafe practices were brought to light only through true cause-analysis. They remained undetected when ordinary accident-prevention methods only were used, notwithstanding their obviousness and the fact that they were improper. Further, these were not the only unsafe practices followed in the plant. Every single operation—literally thousands of varied kinds of work—was subject to criticism from the point of view of safety. Without analysis for *predominating* cause, therefore, the accident-prevention engineer would have no measure of the importance of any one practice and would be obliged to attempt the correction of all unsafe practices, with the result that his efforts would cover too great an area and would be so thinly spread as to be ineffective. As an alternative, he might by guesswork or judgment select certain causes for attention and find later that he had spent time on matters that had little bearing upon the occurrence of accidents in his particular plant.

Although the accident subcause, "willful disregard of instruction," is applicable in each one of the several examples given in this chapter, it should not be assumed that it would apply in all cases. Willful disregard of instruction is a common fault, but it is not universal by any means. Soundly based procedure requires that the real cause of personal unsafe acts be determined before selecting a remedy.

One of the striking advantages of selecting a remedy by true cause-analysis lies in the wide applicability of this method. Coal mines and quarries, steel mills and bakeshops, skyscraper erection and the building of small dwellings—all may benefit, all may and do make use of the same plan, choose from the same set of causes, and apply a remedy based upon the same principles. Industrial operations, large or small, with personnel concentrated or scattered, with or without direct supervision, under cover or in the field, may, except for minor details, solve their accident troubles by identical procedure.

CHAPTER V

CORRECTIVE ACTION

Follow-through.—In sports, the expression "follow-through" has vital significance. It refers to that particular bodily action that comes about through a combination of coordinated muscular and mental effort, stance, poise, grip, and balanced determination and that produces the much-to-be-desired accuracy and power. Power alone is not enough. There must be accuracy as well, and accuracy depends upon the complete knowledge, ability, and practice that permit follow-through to accomplish its objective. The term is here used, however, chiefly as it relates to applied and effective force in dealing with persons.

Follow-through is equally necessary in accident prevention. It is not enough to issue orders and to demand results; it is not enough to express interest and to promise support. The orders must be enforced by subsequent procedure, the interest must be sustained, and the promised support must be forthcoming. There is no need to explain or defend follow-through in accident control, but there may be value in a description of some of its more interesting variations, taken from records of successful application.

In the past, failure to achieve results in accident prevention by executives has not been due to lack of interest or absence of will so much as to the absence of some objective concrete enough to necessitate or to permit customary follow-through efforts to be applied. When prevention work was confined largely to the establishment of a safety organization, the appointment of a safety engineer, the guarding of physical hazards, or the unassisted service of an outside agency such as an insurance company, there was apparently little for an executive to do, other than to arrange for the inauguration of service and to see that it functioned as planned. If accident frequency increased, little if any responsibility was placed upon those in charge of safety, provided they were active. In other words, if meetings were held, inspections were made, physical hazards removed where practicable, and reports in order, accident frequency and accident cost were considered fortuitous. Executives did not fail to participate, but the results of their participation were limited because the program was ineffective from the start.

When, on the other hand, real causes of accidents (unsafe practices and conditions) are known, and, furthermore, when these conditions and circumstances represent man failure that is subject to supervisory control, the executive who has established a suitable corrective procedure and has made sure that it will function properly is in a position to secure satisfactory results.

What executive, for example, could fail to develop a definite course of personal action if he realized the existence of an abnormal and unnecessary operating expense, representing a substantial part of the entire overhead cost and relating directly to efficiency and to volume and quality of product, caused by disregard of orders that he and his associates had issued?

If, in addition, the executive knew what particular instructions were disregarded, if he knew who was at fault and where the disregard existed, and if he knew also that the orders were of a practicable nature, it would be hard to conceive that anything short of death or paralysis could prevent executive action and follow-through.

Yet, such action today is not a too general practice, notwithstanding that the information as to cost and cause is available. This situation is due chiefly to lack of appreciation of ready-to-hand facts.

A better understanding of the situation is rapidly spreading, however, and, wherever it is applied, results in consistent achievement.

In applying a remedy there is a choice of an almost endless variety of methods, as far as detail is concerned, but the principles remain fixed.

How best may executive support be utilized, assuming that predominant causes of accidents are known and that specific unsafe conditions or practices have likewise been located and specified? Contact with many industrial establishments where these principles of accident prevention have already been successfully applied provides the answer. A few examples may be of interest.

Examples Showing Initiative and Follow-through by Executives.—The cases cited hereunder are typical examples of executive action in the successful enforcement of accident-prevention procedures.

The first group of 10 cases represents situations in which the direct and proximate facts of accident occurrence provided ample information on which to base corrective action by the executives. The second group of cases represents situations where it was found profitable to find and make use of "underlying accident causes."

Case 1

This is a story of a business executive who managed a string of hotels and who saved hundreds of men from injury and thousands of dollars in accident cost. One feature is the use made by the executive of his very efficient secretary. Another is the fact that the amount of executive time necessary to accomplish satisfactory results was not more than 10 *minutes a month.*

A good secretary is often irritating and, from one point of view, at least, the more irritating the more efficient. Busy men often dislike to be reminded of unfinished tasks, of forgotten promises, and of procrastination in regard to worth-while action. But at the same time they know that they must be so reminded or action may never be taken.

The executive's action followed overwhelming proof that accident occurrence was responsible not only for injuries and deaths but also for excessive insurance cost, waste, spoilage, delay, lowered morale, and other similar evils. His initial act took less than five minutes. It was expressed in the following instruction to his secretary: "Place before me each month *the essential facts* of accident occurrence." He further instructed the secretary—"and see that after the first report has been prepared I am reminded of it every day until I take action." Thereafter the expenditure of approximately 10 minutes of his time was required each month for a period of six months, when it became feasible to refer the matter to an assistant.

The secretary was of the "sometimes irritatingly efficient" type. It was said of him that he had once had three house detectives forcibly eject his employer from a business conference and put him on board a train, notwithstanding that the trip had been postponed, all because he had been instructed "under no circumstances let me miss that train."

This secretary, after consulting the service engineer of the insurance carrier, agreed that the essential facts of accident occurrence in this case undoubtedly were cost, frequency, kind, and cause. He found that cause was probably of most importance if prevention were to be the objective, and he expressed it as (1) unsafe acts of persons, with the probable reasons why they were committed, and (2) unsafe mechanical or physical conditions.

He received reports on these matters from the insurance engineer covering the several branches and departments, had digests made in brief detail suitable for executive consideration, and presented his first monthly statement. It came back to him the next day marked "noted" but with no comment or other indication of action. Five times he sent the statement back to the executive, each time attaching a slip marked: "You have not yet taken action."

Perhaps such action was overefficient; perhaps it was a source of irritation, but bear in mind that the executive had decided that the matter should receive consideration. The executive knew that it was worth while, and furthermore he knew himself pretty well and also knew his secretary.

Finally, for the first time, 10 minutes was set aside for executive action. Heads of departments having the poorer accident records were called into conference. The meeting was brief and to the point. With the facts before him, the executive said to the head of one department: "Your men persist in storing glasses on the ledges over the steam cookers, in violation of instructions. The glasses fall and break, get into the food, and cause injuries. I want you to see that this practice is stopped at once." Similar pointed remarks were made to each of the other department heads, and the meeting was over.

Subsequently, monthly interviews were held, all of them being of short duration. The department heads were impressed; they recognized their responsibility; they sensed the determination of the chief executive to demand results; and they got them.

The details of procedure are relatively unimportant except that they followed identically the procedure already established for the control of other matters of business routine. The main point is that accident prevention was thus so merged with management and supervision that it received, regularly and effectively, the share of executive consideration that it deserved.

The case here described clearly reveals the value of initial executive action and follow-through. It should serve as a stimulating example to the vast majority of businessmen who do not want employees to suffer needless injury, who are concerned because of high accident costs, and who await only the suggestion of a simple and practicable step before proceeding to do everything within reason to prevent accidents. It is worthy of note that simple and direct corrective action by the executive was made possible only because *the proximate causes of accident occurrence* were found and made available to him.

Case 2

The problem in this machine shop existed because employees generally indulged in conversation with fellow workers while handling material. In the sheet-metal department this habit resulted in unsafe handholds and caused cuts and bruises. Individual foremen were requested to induce employees to keep their attention focused on their work. The foremen were to report their success to the plant superintendent, and he in turn was to recount it to the general manager at meetings held weekly. The first-aid department was ordered to report all *minor* as well as serious accidents to the safety engineer, who was to investigate the causes and location of the accidents and provide a weekly summary for the general manager and superintendent, showing all injuries clearly chargeable to the unsafe acts—gripping material insecurely and distracting attention. These data also were to be used at the weekly meetings. The foremen were held responsible for the enforcement of instruction. The pressure that was thus exerted on the foremen led them to keep the major causes of accidents constantly in mind and to caution employees frequently to avoid laxity. Chronic offenders were found and disciplined. Certain operations were rearranged, thus separating the employees so that gossip and unnecessary conversation were eliminated. By these means morale was improved, and the frequency of accidents was reduced.

Case 3

This case illustrates one of the most difficult problems that is encountered in safety work—the enforcement of the rule requiring the use of guards for operations where there is commonly some doubt concerning the practical value of the guards. Practicability and common sense must prevail in safety as in other things, and it must be granted that it is sometimes hard to provide an effective guard for the point of operation on a circular saw used for a variety of operations. Many excellent circular-saw guards have been devised and are available for purchase. Some of them are adaptable to a wide variety of operations, but much resetting and adjusting is necessary to provide constant protection. In some cases the guard must be removed or swung out of place; for example, when a wide board is split and subsequently grooved on one edge with a variety saw. Further, when sawing very narrow strips ($\frac{1}{4}$ inch or less in width), many of the saw guards are too cumbersome for practical use and interfere with the use of a push stick in forcing the material past the saw. The necessity for constant readjustment of guards, the inherent difficulties in the work, and a certain amount of prejudice on the part of skilled workmen—all these things combined to create a real problem in this cabinet shop with the result that cuts and amputation of fingers occurred to employees from unguarded saws, jointers, and shapers on which guards were misadjusted.

In the case under consideration the executives had weighed the matter carefully and had decided that effective action of some kind was needed, although they were seriously in doubt as to the existence of a better method than that of redesigning the guards. When the man-failure subcause of accidents (disregard of instruction) was first presented to them, however, they began to see their way more clearly.

The prejudice of old-time employees against protective appliances and their lack of sympathy with orders to keep guards properly adjusted were disturbing factors. But when the executives realized that man failure was the root of the trouble and that they had previously encountered and solved many production problems arising from the same cause, they were no longer in doubt as to the solution of the difficulty.

The situation was frankly explained by the mill superintendent to the foremen, at a group meeting. The attitude of the company with regard to safety was explained. So, too, were the specific causes of accidents (unguarded point-of-operation and misadjusting guards). The foremen were asked to cooperate and specifically were requested *not to sympathize* with workmen who complained about the delay and inconvenience involved in readjusting guards for short jobs. They were instructed to make it a part of their daily routine to see that orders concerning the use of guards were effectively enforced. In short, "the impossible" was attempted and, as it so often turns out, was found to be not only possible but also an accomplished fact. At first the workmen complained, but gradually by constant insistence the new program was put in force and became a fixed part of routine. The accident frequency dropped appreciably in the first six months, although among the few accidents that did occur was one serious case. During the next six months a still lower frequency prevailed, and there were no lost-time accidents. The record for the full year, for both frequency and severity, was more than 50 per cent better than that for the preceding year.

The particular variation of follow-through here used consisted in personal inspections of the mill room by the mill superintendent. These visits were for the express purpose of observing misadjusted guards and enforcing corrective action on the spot. They were made semiweekly for the first month, and once a month for the next five months, when they were discontinued because they were no longer considered necessary. The employees were impressed, and the foremen were keyed up and made alert by the manifest sincerity and interest of their superiors.

Case 4

Results in this chrome-leather tannery were relatively easy to obtain, once it had been determined by analysis what the facts were. It was evident that accident *severity* was more disturbing than accident *frequency*. Employee failure to report minor cuts to the first-aid room for immediate treatment led to chrome poisoning in some cases, and many of the wounds became infected—one especially serious case resulting in the loss of a hand by amputation. Finding that accident frequency in itself was comparatively low, the procedure that is ordinarily followed was reversed in this case, and attention was concentrated first upon the *control of infection* and later upon the prevention of the original injuries by means of the customary attack on specific accident causes.

The particular variety of executive action here used successfully consisted of personally dictated and signed notices posted conspicuously each week, drawing attention to different phases of the situation. A special notice was prepared and posted in each case of delayed first-aid treatment. The name of the employee was given, all the circumstances were described, and a résumé of infections resulting from other similar delinquencies was included. The executive personally obtained complete information. For one month he insisted upon a daily examination of the employees' hands by the foreman; and by personal inquiry and investigation succeeded in establishing the practice of immediately reporting minor injuries for first-aid treatment.

Case 5

The type of accident, in this instance, was not unusual in trap-rock quarry operations. After blasting, it was customary to scale down the working face to remove loose rock that might otherwise fall unexpectedly upon the men working below. This was often carelessly done. At regular intervals, as the working face was cut back, the topsoil or overburden was removed. In this stripping operation, loose rock and soil were often left close to the edge of the face and sometimes fell down upon the employees. Cars were loaded, at times, in a haphazard manner, rock fell off them, and workmen were injured. Employees stood between cars while coupling them.

If these unsafe practices and conditions had received proper consideration, the accident-prevention problem would have been comparatively simple, but for a long time no suitable corrective action was taken because of an improper conception of the situation. The injured employees were considered to be at fault, whereas, in reality, the foreman of the scaling crew and those in charge of the stripping and loading operations were chiefly responsible. This responsibility was indicated by the fact that the foremen not only permitted the unsafe practices to go unchecked but had so ordered and arranged the work that it was often difficult for the employees to follow safe procedures.

When the actual facts had been determined by analysis, orders were issued that safe practices must be enforced, and the executives in following through adopted a method that is a bit unusual in quarry operation.

It was customary for the general manager and all superintendents to meet weekly, for one hour, to discuss problems concerning cost, production, new orders, personnel, and other related matters. The timekeeper acted as secretary at these conferences. He kept the minutes of the meetings and presented them for approval and, in addition, prepared an agenda for discussion. He was instructed to include a new item (accident prevention) in the agenda for all future meetings and was authorized to provide data relating to it.

At the next meeting he read the following rather startling note:

> Accident prevention: Major trouble is "failure to enforce instruction" with regard to safe practices in scaling quarry face, removing overburden, and loading cars. Progress has not yet been made. It has not been necessary to remove overburden since our last meeting, but neither has the crew been instructed as to proper practices. Men still load cars in such manner that rock is jolted off; and a fall of rock caused by improper scaling occurred Wednesday noon, after scaling had been reported as completed. Fortunately no one was below at the time. Injuries have occurred, however, from rock falling off cars. The general situation remains as unsatisfactory as at our last meeting.

As can well be imagined, a spirited discussion followed, and a plan for more effective action was devised and put into operation at once. In a short time accident frequency was brought under control, and subsequently a splendid record was made in the reduction of lost-time accidents and in reduction of expense. This type of follow-through may be described as "making a place for accident prevention" on the official records of the company.

Case 6

In this rubber-tire plant there was a high frequency of cuts and bruises from slipping tools, burns while handling hot molds, collisions with fixed objects, and falls from working platforms. The plant was large enough to support a department of safety with a capable engineer at its head, who was ably supported by a competent staff. Records containing pertinent data were kept. System and method were consistently used not only in manufacturing tires but also in connection with other activities, including safety. The great importance of minor or first-aid accidents from a statistical and cause-analysis point of view, and as an indicator of ultimate lost-time accident frequency, was realized, and it was decided to measure results in individual departments by the *over-all* accident record rather than by the more serious injuries only. It was anticipated that there might be some attempt at concealment of injuries, if this were done, but it did not materialize to any great extent. Nor is such concealment to be expected where proper supervisory methods exist, because, in principle, it is no different from expecting that workmen would conceal defective products simply because of fear that they would be reprimanded. In both cases, detection of such delinquency is bound to occur ultimately, and the results then are usually so much more embarrassing that the lesser evil for the employee is to report the accident or the defective material at once, as instructed.

As the result of minor accident analysis, causes were found to be similar to those that had resulted in lost-time cases. The unsafe personal acts of most significance were pulling wrenches toward the body, using extensions on wrench handles, failure to wear gloves when handling hot molds, and placing objects in passageways. The mechanical hazards were unguarded platforms and congested work spaces.

The subcauses of accidents (reasons for the unsafe acts of employees) were a bit doubtful. It was a question as to whether the existence of unsafe practices might not be directly chargeable to the departmental foreman rather than to employee fault. The decision was reached, however, that in this case there was little choice, since both causes were typical of man failure and were controllable by foremen when specific unsafe practices and conditions had been determined. For example, employees who disregarded instruction could be made to follow safe procedure if the foremen were sufficiently alert and "safety minded" to enforce instructions relating to the safe handling of tools and equipment. Thus both causes could be attacked at the same time by the improvement of supervisory methods.

In applying executive initiative and follow-through at this plant, use was made of the excellent existing organization and system. A merit-production system was being installed whereby individual workmen (and foremen also) received wage bonuses if they exceeded production expectations on work of uniform or standard nature. Accident occurrence was introduced as a factor in this new system, with the result that wages were affected not only by production but by safety as well. As can well be imagined, the loss or gain of premiums through the workings of this plan became at once an absorbing topic for discussion. Accident prevention was accepted in an entirely new light; interest in it was maintained; causes and prevention effort were studied more carefully; and more effective and more consistent safety work was done. The reports concerning both production and safety automatically came before the executives, who were then in a position to use their personal influence to better advantage.

In addition, the works manager wrote personal letters to each department head, using as the basis the information given him monthly by the safety engineer. He also personally interviewed department heads when results as to accident frequency were unsatisfactory. He attended safety meetings, and otherwise through personal contact made accident prevention a part of his routine work, following its progress just as he followed the progress in volume and quality of output and in the cost of production.

In all this activity emphasis was consistently placed on the *specific accident causes* that had been determined by minor-accident analysis.

Case 7

A furniture-manufacturing plant. Realizing that the new accident-prevention program embodied features that were unfamiliar to many of the employees, the general manager held two meetings—one of the superintendents and another of the foremen. He addressed each meeting personally and was seconded by the production manager at the superintendents' gathering and by the general superintendent at the assembly of the foremen. The outline of his brief and forceful talk was the same in both cases.

He referred to both humanitarian and economic motives for accident prevention and stated that the company and he, personally, were determined to better existing conditions. He said that the causes of accidents were known, and named them, and also referred briefly to some of the specific unsafe practices and conditions. It was made clear that, beginning immediately, accident prevention was to be considered as a routine and an important part of regular work—just as much so as quality and volume of product—and that because accidents admittedly occurred by reason of the same faults that affected general efficiency, they could no longer be treated merely as unfortunate happenings. Most important of all, he said that the performance of each man as to progress or lack of progress in the elimination of accident-producing conditions would be made a matter of record and that on the basis of such record he proposed thereafter to hold those having supervisory positions personally accountable. Later, at other meetings, each foreman addressed his own group of men, but these gatherings were not attended by executives.

The general manager kept his word as to charging executives with responsibility at regular intervals thereafter, until satisfactory results were attained. Frequency and severity rates decreased rapidly and materially. Certain other details (although these were few and involved little expense) were included in the prevention program. For example, the insurance company was invited to reanalyze the situation every three months and to present a report with necessary modifications as to specific accident causes. Each such report was used as a basis for further consultation between the general manager and his staff. It was the consensus among all executives that the two outstanding factors in effecting the change from abnormal to better than normal conditions were; first, the identification of the pertinent facts of accident occurrence. and second, the marked impression made upon the entire plant personnel by the forceful participation of the chief officer of the company and by the fact that he personally expressed his intense interest and insisted that improvement be made.

It is in order to remark here that executive participation and support are a source of inspiration and are worth while under any circumstances but that by themselves they will lead to little of concrete value. They must be supplemented by proper analysis which will disclose true accident causes—unsafe practices or conditions of a definite nature—so that the foremen may know what they are expected to correct and for just what they are to be held accountable.

Case 8

A die-casting and instrument-manufacturing plant. In this case injuries in considerable frequency had occurred because employees disregarded instruction that punch-press guards should be kept in proper adjustment, that all presses should be guarded before new operations were under way, and that stock pans and boxes of raw and finished material should be kept out of the aisle spaces.

The chief executive was a detail man. He disliked the idea of holding meetings but believed in direct personal and individual contact. He was willing to spend considerable time in the improvement of the plant situation but decided to hold no meetings and to have no so-called "safety organization." He did, however, arrange to have his safety engineer, in cooperation with the service engineer of his insurance carrier, present a semiweekly report of all misadjusted punch-press guards, of presses unguarded, of violations of instructions concerning placing of material in aisle spaces, and of the reasons why employees committed the named unsafe acts. Upon receipt of this information he visited the departments concerned, personally verified the information, and then, on the spot, proceeded to take the foremen to task.

This is an example of executive support on a basis that could not well be applied in every organization. The method was decidedly effective, however. The desired impression was created, unsafe practices and conditions were eliminated, and accident frequency, from the causes named, decreased.

CASE 9

A furniture factory. The executives in this midwest plant found that it was advantageous to maintain a reasonably close social contact with the foremen. Local conditions and circumstances favored such relationships. The expression "one big family" typified the situation, and there were bowling clubs, baseball and tennis teams, and an annual get-together and dinner that was attended by the president and his staff and by all executives down to and including the foremen.

Having reached the point where analysis had disclosed specific unsafe practices and conditions, it was decided to spread an entirely new message (as the accident program in this case was termed) at the annual dinner. This was done by the president himself who expressed in friendly but emphatic language certain thoughts with regard to accident cost, relation of accidents to production, accident causes, and supervisory control. He closed his remarks by stating that a new leaf was being turned, that he wanted results—expected and demanded them, in fact—and would personally see to it that they were forthcoming.

The works' superintendent then outlined a simple plan of procedure, which in effect meant that accident records by departments, showing frequency, cause, and type, would be prepared monthly and compared with the average record for the preceding year and that each foreman was to be charged accordingly.

A spirit of friendly rivalry was thus established, and the results were most encouraging.

CASE 10

A tunnel-construction contract. Cause-analysis in connection with this contract had indicated that poor health, ignorance of safe practice, and lack of conviction that certain activities were really unsafe resulted in the following unsafe practices: Sand hogs entered air locks while in temporarily poor physical condition; barrows of rock were dumped from runways without making sure that all was clear below; men rode up and down shafts in material buckets, exposed themselves at the bottoms of vertical shafts, and rode the bumpers of muck cars.

Time was at a premium on this particular contract, and the men were engaged in work that was physically exhausting. It was therefore impracticable to hold meetings at which executive participation in and support of accident prevention might be expressed in talks. Consequently, the expedient of circulating letters, bulletins, and warning notices, and thus arranging for contact with the workmen, was chosen as the method to be followed in the new safety program.

The general superintendent, who was also part owner of the company, wrote a personal letter to each superintendent and foreman. Each unsafe practice that had been selected as typifying one of the chief causes of accidents was made the subject of a bulletin which was posted at strategic locations. Each foreman received weekly a list showing the number, causes, and types of the injuries that had been sustained by his men. When orders for work were given out they were accompanied by an admonition to avoid the practices that had already caused injuries. Foremen were verbally instructed to caution men more frequently and to be more insistent that the men follow safe practices—the particular practices requiring special emphasis being named in each case. The general superintendent and his assistants, when making inspections, invariably included, in their comments to foremen, remarks concerning specific unsafe conditions as well as the amount and quality of the work performed. In short, the particular conditions that were responsible for the existing accident frequency were emphasized repeatedly by the higher executives, until the desired impression was created. In this way official support was extended without introducing red tape or causing extra clerical work or unnecessary delay.

Examples Showing Corrective Action by Executives When "Underlying Causes" Exist.—As pointed out in Chap. IV, it is sometimes necessary to find causes that underlie the mechanical or physical hazard, the personal unsafe act, and the reason for the unsafe act. The necessity for such further research in fact finding is indicated when sound corrective action based on the *direct and proximate* causes is not effective.

CASE 1

In a fertilizer-manufacturing plant, the direct and proximate cause of most accidents was known to be violation of rules to use life lines when entering storage bins—the reason for the unsafe act being shown to be willful disregard of instruction.

Corrective action consisted in reprimands and warnings of penalty, also repeated orders to foremen that they must strictly enforce the rule.

Further violations occurred, and additional injuries were reported.

The underlying cause was eventually traced to an improper attitude on the part of two foremen. When one of these men was asked why he thought an injured employee violated the rule in question he said, "How the——do I know? I wasn't even in the department at the time. I can't stand over every man and wet nurse him continually. If the men haven't sense enough to take care of themselves, they ought to get hurt."

The management, having found that this expressed attitude was more deep-seated than superficial and that in some degree it existed in one other foreman, made certain supervisory adjustments that effected an immediate improvement in the violation of the safe-practice rule under discussion.

Case 2

A chain-store organization suffered a poor public-accident experience from the combination of the mechanical hazard "vegetable debris on floors" and the unsafe practice "throwing or failing to remove debris from floors."

As the result of applying the kind of accident cause-analysis herein described, the man-failure subcause for the unsafe act was determined to be "inconvenient and nearly impossible."

In other words, the employees were fully aware of the hazard due to vegetable debris on floors and were quite willing to keep the floors clean, but because brooms were not conveniently available and because containers were not accessible it was practically impossible to maintain safer housekeeping conditions. Their problem was made more acute because vegetable tops, lettuce leaves, grapes, etc., were knocked off the counters by customers *during rush hours.*

The reason for the specified unsafe act thus directed attention to an underlying managerial cause, namely, failure to provide adequate equipment.

With the further assistance of the service engineer it was decided first, to place a short-handled broom in a rack at each counter end and second, to provide conveniently located rubbish boxes.

Accident frequency dropped within a week and over a period of six months declined to a point where it was considered better than normal expectancy.

Case 3

A high frequency and severity of employee accidents existed in a group of chemical manufacturing plants.

Proximate and direct accident causes had been developed. However, even with adequate knowledge of such specific facts the accident experience had not improved. The ultimate disclosure of underlying managerial and supervisory fault led to the conclusion that it was more important in this case to remedy the underlying fault than to ignore it and to feature the correction of outstanding unsafe practices and mechanical hazards by the use of existing executive attitudes and procedures.

These plants were but one group of several subsidiaries of a large concern. When the problem became so acute that it necessitated consideration by the home-office executives, facts were developed as follows:

The local executives were "too busy" to initiate and direct safety work. Production was placed so far above safety in importance that the latter was practically ignored. A wrong conception existed as to the relation of safety and production and also as to the effect of accident cost on net profit. The local plant executives were reluctant to listen to the advice of the safety engineer of the insurance carrier. In short, at these plants no attempt had ever been made to establish safety work on an orderly and systematic basis nor was there the probability that this would ever occur unless because of a "jolt" from some respected source in the industrial organization itself.

Such a jolt was finally forthcoming. An executive order was received direct from the president of the parent company which required:

1. The chief executive to establish immediately a central safety committee.

2. The chief executive himself to act as chairman of the committee.
3. The appointment of a full-time safety inspector and also of a safety committee in each plant.
4. That each plant superintendent spend one full day of each week *wholly on accident-prevention work.*
5. That necessary forms be provided, accidents properly investigated, job analyses be made, responsibility be placed, safeguards installed and in general that safety work be carried on in the future in an orderly, systematic, and effective manner.

Finally, provision was made whereby the chief executive of the subsidiary group of plants was to make a personal report of progress to the home office of the parent company.

Needless to say the subsidiary executives were not "too busy" to attend to safety work thereafter. As a matter of fact, their attitude was not *inherently* faulty, and when they were finally aroused to the importance with which safety was regarded by their superiors, they entered into the program with zeal and managed to accomplish amazingly good accident-prevention results while at the same time improving the quality and volume of production.

Case 4

Accident cause-analysis in the case of a large commercial trucking company showed the outstanding unsafe act to be "following the vehicle ahead too closely."

An alert and efficient management had followed customary prevention procedure without much success, and collisions, property damage, and personal injury still occurred. Instructions to follow at a safe distance and speed had been issued, and a reasonably determined effort at enforcement had been made without satisfactory results. Much safety educational work had been done. In addition, the disclosure of the personal subcause—defective vision, had led to the fitting of drivers with corrective glasses. This helped some but left the general situation still troublesome.

It was finally necessary to consider possible underlying causes, thus disclosing the fact that an inadequate employment program was in effect. Applicant drivers were examined thoroughly as to knowledge and previous experience, and limited physical examinations were also made. The applicants were not thoroughly examined, however, for defects in vision, especially depth perception. This omission coupled with a relatively high and uncontrollable labor turnover led to the employment of drivers who could not properly judge safe following distances.

Suitable changes in the employment program were made, after which no further trouble was experienced from the practice of "following too closely."

It should not be concluded from these four examples that it is either necessary or advisable to search for underlying managerial and supervisory faults in all accident problems. More often than not such faults do not exist to any serious extent. Further, even when they do exist, the more direct and simple approach based on knowledge of proximate accident causes leads to their disclosure more or less automatically.

An indirect, homely analogy may illustrate the point. A piano salesman discovers a prospect who *wants* the make of piano that the salesman handles and who not only has the money to pay for it in cash but is also willing to pay it. If the salesman says to the prospect, "I can have a baby grand delivered to your house next Monday. It will cost you $1000. Will you buy?" and the prospect says "Yes," what need is there to expound on comparative merits in tone and action, material and finish, etc? What need is there to appeal to the prospect's ability to envisage the quality of the instrument or its value in the musical education of his children?

However, should the direct approach fail or should it be obvious that it would probably fail if attempted, there is sound defense for gathering and using underlying facts. Incidentally it need hardly be stated that there is a considerably greater likelihood of getting results by direct methods in accident prevention than in piano selling.

The cases described here embody the general principles of accident prevention discussed in preceding chapters. In each one of them, however, the chief aim has been to indicate the way in which some of the simpler methods of executive follow-through are employed under different conditions. Further exposition of executive methods of obtaining results would be beyond the scope of this book. It is enough, perhaps, to repeat that executive machinery, as it exists today for the control of quality and volume of product in any well-organized industrial establishment, is adequate to secure and maintain reasonable freedom from accidents—it merely needs to be extended to include accident prevention, without change in method. The chief essential is to *provide facts* of real value in accident prevention, to determine the unsafe practices and conditions causing the accidents and the reasons why such practices and conditions exist.

Safety Administration.—It must be granted that the inauguration and subsequent functioning of any industrial procedure, be it cost accounting, selection of personnel, training of personnel, manufacturing process, bookkeeping, or sales, should have executive support. The most nearly perfect remedy for accident occurrence, likewise, would suffer in application and successful continuance if executive support were lacking.

Second, just as it is true with regard to production and sales that responsibility must be placed upon capable and trustworthy persons and that these individuals must be charged with, and made to account for, their records of achievement, just so is it true that persons with similar characteristics should be held responsible for accident-prevention work and made to account for the occurrence of accidents.

In the larger industrial operations there are one or more safety engineers who devote all or a part of their time to safety work. There may also be safety committees of various kinds, perhaps an employment or personnel manager who supervises accident prevention, or a manager of a so-called "department of health and safety"; and there are executives who are in a position to spend at least a small part of their time in the administration of safety activities. In short, there is an organization already in existence and available for the application of a practicable accident-prevention program. In the smaller plants a single executive may be obliged to assume the duties (or, at least, the responsibilities) that under other circumstances would be taken over by several employees. Foremen or supervisors, as such, are not always included in the personnel make-up of all branches of industry.

In all cases, however, the principles governing the successful application of a remedy in accident prevention remain the same.

and variations in circumstances merely require adaptation of details in method, made necessary by existing conditions.

The Small Plant.—Executive support is available even in a typical one-man plant where the employer himself is production manager, salesman, superintendent, and foreman. He must personally select the remedy for accident occurrence or delegate the task to one of his employees. He must also issue and enforce orders with regard to the application of the remedy, and he alone must accept the responsibility for failure. If the limited amount of time required for accident-prevention work cannot be found in a plant so small as to fit this description, then there is little hope of accomplishment. This situation, however, does not reflect on the methods herein proposed but rather on the management of the plant, which would fail as regards sales or any other procedure if proper executive supervision were omitted because of cost or lack of time.

Employees Are Paid to Work Safely.—These preceding examples illustrate a few of the many ways in which executives may lend support to a plan for accident prevention in a practicable and businesslike way, thereby fulfilling the requirements of the first fundamental of the application of an already determined remedy. Perhaps the one point of most value may be expressed as the necessity for asking for what we want if we actually hope to get it. It may be pleasanter, although less direct, to allow individuals to *infer* that something is wanted, with the hope that eventually they will themselves decide to do something about it. In business generally, however, these unnecessarily diplomatic preliminaries are often omitted. Producers are told to produce, and salesmen to sell, and definite requests are made by authorized executives along these lines. Good management and diplomacy of course require the use of tact, common sense, and variation in the method of making these requests. Granting that foremen are paid to run their jobs and supervise their men in all respects, employers clearly have a right to demand of them that proper measures be taken to control accident-producing conditions.

Responsibility for Accidents Must Be Placed.—When cause and remedy have been determined and executive interest and support have been extended to the accident-prevention plan, the next step is one of placing responsibility upon the foremen or supervisors.

One important fact stands out clearly; it makes little difference whether faulty conditions exist because the workman is remiss or because the foreman has been lax. The conditions can best be corrected by the foreman, and when the burden of responsibility for results is placed on his shoulders, he must determine where the fault lies and correct his own shortcomings if necessary. If, as may sometimes be the case, he finds that he lacks authority to make the desired improvement in conditions, the insistent demand for results will justify him in making the truth of the matter known to his superiors.

From every point of view, it is evident that, once the program has been approved and has received executive support, the first real action must be taken by the foreman. When the unsafe conditions and practices that are chiefly at fault have been identified and located, they must be attacked. It is unnecessary to elaborate on the many ways and means at the disposal of the foreman in directing the activities of his workmen, in getting them to perform their work safely by avoiding unsafe practices and conditions and by following safety rules, since this would involve a discussion of facts that are already well known.

Success in general supervision is a subject that does not fall within the limitations of this work on accident prevention. Capable employers, executives, and foremen know well how to get results from workmen. Established business procedure that has been proved by long experience makes use of such factors as encouragement and praise, admonition and warnings, insistence, demand and definite orders, repetition of demand, argument, stating of facts, comparison, records, inference, promotion, bonuses and prizes, contests, merit-rating systems, and fortunately, to a lesser extent, penalties, threats, and discharge. In this connection, reference is made to Chap. III.

By and large, if employees are requested to carry on their work according to practicable and fair instructions, and if the executive knows exactly what he wants and expresses his desires clearly, he has every right to expect compliance. The whole matter of getting results in accident prevention through the foremen, therefore, once the causes and conditions have been specified, may be summed up as issuing orders and enforcing them by use of ordinary executive methods.

Without extended discussion of these well-understood methods, it might be of interest to point out certain high lights among them that have been emphasized by individual executives with surprisingly good results.

CONVINCING THE FOREMAN OF HIS RESPONSIBILITY AND ABILITY TO CONTROL ACCIDENT FREQUENCY

Case 1

A rolling mill and smelting works had a high frequency of accidents—both major and minor. The predominant causes of both types had been determined by analysis and found to be alike. The remedy lay in more strict enforcement of orders and required that the individual foremen realize their responsibilities and make it a part of their work to detect and correct improper and unsafe practices on the part of the men.

A general meeting of all superintendents and foremen had been held, but the foremen had failed to respond satisfactorily. The executives were frankly discouraged and believed it almost impossible to materially alter the attitude of the foremen. The service engineer of the insurance carrier volunteered to convince the most "hard boiled" of the foremen and stir him to action. His offer was accepted and the trial was made.

After certain facts with regard to his accident record and his experience before employment had been ascertained, the foreman of the yard-maintenance department, where a high frequency of minor accidents prevailed, was called into the general manager's office. He was a typical "hard-boiled" specimen, with a morose look on his face. He did not remove his cap or his leather jacket, nor did he make any attempt to conceal the presence of a huge chew of tobacco in his left cheek. After the introductions had been made, the general manager said: "We believe that you can prevent a great many of the accidents that have been happening to your men. The cause apparently is that the men do not follow the rules for safe practices that have been made. In particular, they do not use the proper tools and they take chances while handling material. This man here (indicating the service engineer) wants to talk to you about it."

The foreman, after a cursory and highly unflattering inspection of the stranger, paid no more attention to him—in fact, did not give him so much as another glance until the interview was well under way. He was obviously impressed, however, by his unusual and rare contact with so high an executive as the general manager and, to cover his momentary lack of composure and perhaps to fortify his sense of personal independence, he looked about for a cuspidor and, finding none, shot an accurately aimed stream of liquefied plug into the near corner of the room, folded his arms across his leather jacket, and waited.

At one time this foreman had been a water tender in the boiler room of an ocean liner. This was known to the service engineer, who had held a similar position and who now realized that a conversation on this familiar subject might result in gaining the foreman's confidence and pave the way for a friendly discussion of accident prevention. He therefore began with a story of a boiler-tube failure under "closed-fireroom" forced-draft conditions. As a result of their experience, both men knew that when a boiler tube "lets go" under such conditions, it would be fatal to open any of the boiler-room doors, since this would cause the air pressure in the room to drop. The scalding steam and water that would then pour out of the boiler (instead of being forced inward by the pressure of the air, as would be the case if the doors remained closed) would probably kill all the men in the room. The commonly known and approved action in such a case is to speed up the forced-draft fan, cut out the boiler, and, above all, keep the boiler-room doors and hatches closed under any and all circumstances.

The point in the story had been reached where, in a frenzy of terror, one of the firemen had started up the iron ladder, with the evident intention of tripping the hydraulic control of the upper hatch door and escaping at the sacrifice of his fellow workers.

The foreman was now displaying faint but visible signs of interest. Then suddenly he was asked: "Would you have been able to stop this man from opening the hatch?" The reply came without hesitation: "You can bet I would." Then the following conversation, intensely illuminating, when causes and remedies for the occurrence of industrial accidents are considered, took place.

"What would you do? Suppose he kept on going up?"

"He wouldn't go up."

"Suppose you weren't looking, didn't see him as he started?"

"I'd see him, all right. I'd expect some fool to do a stunt like that, and I'd be on the watch for it."[1]

"Suppose he paid no attention—said he had something else to do—had no time—thought you were wrong—deliberately disregarded your orders to come down, or was so panicky that he didn't know what you meant? Suppose he didn't hear you and there was no time for argument?"

"Say, listen, mister—he'd hear me all right and he'd have time and he'd do as I said. If I was in charge, it'd be my job to run that boiler room and all the men in it. He'd get no farther than the second rung of the ladder if it took the biggest coal scoop we had to bring him down."

This was a long speech for this taciturn foreman. The point was made. The general manager accepted his opportunity and said:

"All right, Frank, that's splendid. Now why can't you stop some of these men of yours in the yard from doing silly and careless things that cause accidents to themselves and to others?"

"That's up to you," said the foreman.

"Why up to me?" replied the general manager. "I pay you to run your department and run it safely."

Again the foreman said; "It's up to you. If you say it's my job to stop these accidents and will back me up, "I'll stop 'em."

"That is exactly what I do say. I don't want them to happen. They cost money and they cause suffering. I'll back you up, so go ahead and stop them, and begin right away. But just a minute, Frank (as the foreman abruptly turned and started for the door), no coal scoops—mind, now, we don't want to cripple our men trying to save them from scratches."

All in all, it was a most interesting interview; but the incident was not yet closed. Through the large glass windows of the office

[1] Here is the real key to the control of accidents by foremen, to know the probable causes of accidents in advance and to look for them and correct them before accidents happen.

a part of the yard—the domain of this yard-maintenance foreman—was visible, and the foreman could be seen as he started across it toward his office. It required no keen judge of human nature to perceive that he was figuratively a new man—that he had an entirely new conception of his work—that he was impressed. He stopped a moment to button up his coat, tweak down his cap, and "wash" his hands with the motion so naturally used by a man who has just come to a sudden decision and a resolve to accomplish something. Then he started looking around as he walked. Undoubtedly he was looking for accidents—for unsafe practices and conditions before they caused injuries—and to the intense interest of the two men now in the general manager's office, he found one of them.

A dinky locomotive engine and a flat car loaded with bales of metal scrap had just turned the corner of a building when one of the bales, weighing probably 500 pounds or more, fell off and came to rest on the rails. A laborer (one of the employees in the yard-maintenance department) took a thin board from a pile neatly arranged against the building and was in the act of using this obviously improper and unsafe tool to pry the bale off the rails.

From a distance of fully 50 yards, the foreman, now fully conscious of his responsibilities and on the alert for conditions that lead to injuries, began his work of prevention. Unfortunately his remarks were not audible in the general manager's office. They were undoubtedly to the point, however. His actions, moreover, were intelligible and satisfactorily convincing.

He instructed the laborer to place the board back on the pile and to go and get a crowbar. Apparently this man had been so advised on other occasions. At any rate, he waited until the foreman had turned his back and walked off, then again started to use the board. Impressed by his recent interview, the foreman suddenly looked back, witnessed the act, and applied more emphatic measures. Being convinced by this time that his boss meant business, the laborer threw down the board in disgust and walked off. He had taken only a few steps, however, when the now thoroughly aroused and newly converted exponent of safety clapped a heavy hand on his shoulder and said something that resulted in the board being picked up and laid carefully on the pile where it belonged. Presently the laborer came back with a crowbar from the tool shed, pried the bale out of the way, and went off to notify the transportation unit that the small railroad crane would be needed.

The incident was over, and with another shake of the shoulders and tweak of his cap, the foreman was off looking for more worlds to conquer.

This illustration is quoted in detail because it so vividly portrays (better than cold impersonal statements could possibly do) some of the principles of accident prevention already set forth in this chapter. Foremen actually can be, and should be, made to realize that they are responsible for accident occurrence, just as any executive is responsible for the work placed in his care, even when the actual operations are to be performed by others with whom he is not always in direct contact.

Foremen can prevent accidents, if they really want to, and if the executives make it clear that they, too, want it done. A foreman need not be told how to get results when these may be obtained by the same methods by which quality and volume of production are secured. It is an axiom of executive psychology that even the apparently impossible may at times be demanded of a subordinate, on the basis that thought and action may lead to the desired result, perhaps through newly developed but wholly practical channels.

Case 2

A case in point is that of a hardware plant where the frequency of accidents from burrs and sharp edges while handling sheared material was abnormally high. All ordinary methods had failed to reduce this frequency. Unusual care had been taken to keep the dies and shears sharp and properly adjusted. This had proved helpful, but the conditions had not been improved sufficiently. Gloves with wire insertion in the palms were supplied, and automatic handling equipment was provided for certain operations, with little effect upon the occurrence of injuries.

Finally, at a safety committee meeting, the plant superintendent emphatically stated that something was decidedly wrong, but he didn't know just what it was, and that he was going to put it squarely up to the foremen to produce results. He said that he did not propose to tell them how—that was their business and was one of the things they were paid for. He demanded improvement and left the meeting in high dudgeon. Within the week one of the foremen advanced the suggestion that certain objects, then being manufactured out of sheet metal, be cast in molds. Although at first thought this seemed to be utterly impracticable, experiments were made and it was found that the manufacture of malleable iron castings was cheaper, the product was better in every way, and the process was safer. Nowhere is it more true than with regard to accident prevention, that necessity mothers both invention and accomplishment.

Case 3

In another case, the management of a large paper mill had become thoroughly convinced of the humanitarian and economic significance of accidents. They were informed as to causes, specific unsafe conditions and practices, and remedy, but they found it hard to convince their foremen that it was fair to charge them with responsibility. The foreman of the machine-repair department was the most obstinate of the group, and it was believed that his conversion would have a beneficial effect upon many of the others who looked upon him as their model in many ways.

This foreman was highly intelligent. He was a clear thinker and possessed no mean ability to argue. He was converted by drawing an analogy between his position and that of a police official in charge of traffic—he himself having drawn a similar analogy, but from the opposite point of view. Discussion had taken place concerning one of his workmen, a lathe hand, who persisted in the practice of brushing off chip accumulations with the heel of his palm, when they curled up, hot and jagged, from the blue chip steel cutting tool, while he was dressing down rolls. A hand brush was available for this purpose, and he had also been told that on roughing cuts it was permissible to stop the lathe, but he openly disregarded the instruction and had already twice been injured.

The foreman said: "What am I going to do except fire the man? None of us wants to do that." Then he added: "All men break rules occasionally. Look at the apparently intelligent pedestrians who cross streets against the traffic lights. I do it myself at times. Everybody does it. You just can't get men to do what they should do."

The secretary and treasurer, with whom he was arguing, then related the following incident:

He said: "While visiting a near-by city not long ago, I was guilty of jay walking, just as you have indicated. I wanted to cut across a street to get to a cigar store directly opposite, in the middle of the block. People, hundreds of them, were lined up on the sidewalks but the street was bare. I looked both ways. No traffic was in sight, and as in my judgment it was entirely safe to cross, I stepped off the curb. I crossed the trolley tracks and was within 15 feet of the other curb when, with a tremendous clatter, a mounted policeman drove his horse between me and the sidewalk, reared the prancing and spirited animal up on its hind legs, and then caused him to sidestep so close to my toes that I was forced to retreat. I moved slowly and with dignity at first, but as the horse kept crowding me I was obliged to turn tail and make a dash for the place I had come from. The officer pursued me over the sidewalk and to the store fronts and then dismounted, while the appreciative crowd, that had apparently gathered in the hope of witnessing just such an event, roared with laughter. The officer said: 'Do you happen to be from out of town, sir?' 'Yes, I am a stranger here,' I replied. 'I thought so. Well let me make it clear that we are campaigning against jay walking in this city. We have traffic rules and they are made to be obeyed and not to be ignored. We mean business. If you want to cross this street go up to the next corner, wait for the green light and cross in safety. Good-bye, sir, and good luck to you.'

"I maintain, therefore," continued the secretary, "that it is entirely possible to enforce even traffic regulations if the will and executive support exist, and if the enforcement officers are capable. They had good enforcement in that town—good foremen, if you please—and I may add that I follow the police regulations to the letter—at least whenever I am in that particular place."

The foreman agreed that although handicapped a bit by lack of a spirited mount, he nevertheless could probably find some way to get his men to obey instructions.

In all these illustrative cases there was executive interest, knowledge of specific unsafe practices, and in all cases responsibility was placed on the foremen.

The foreman upon whose shoulders the burden now rests must begin his work. In trying to control injury frequency, however, he is often puzzled because the injuries are not frequent. He may, in fact, wait for one to occur so that he may then make use of his opportunity to improve conditions. He may have few such opportunities in a limited period, however, and, meanwhile, interest is likely to wane, the impression created by his superiors may wear off, the injuries (when they do occur) may be widely different as to cause and type, and he may feel that for the moment there isn't much to do. This is a grave mistake. There are imperfections in every industrial operation, and successful accident prevention requires unceasing thought and effort. The trouble generally lies in the failure to appreciate the marked distinction between an accident and an injury. If this distinction is fully understood, much can be done to stop accidents before they result in injuries.

Foreman the Key Man.—There is little need for substantiation of the oft-repeated assertion that the foreman is the "key man" in industry, that he, from an executive point of view, is responsible for accidents, and that he is the man upon whom dependence must be placed for the maintenance of practices and conditions that control quality and volume of work as well as safety. There is, however, real value in emphasizing the assertion. In fact, it is so vital a factor in accident prevention that an address on this subject is reproduced in full in an appendix.[1]

HANDLING-OF-MATERIAL ACCIDENTS

The interest displayed by industrial executives in accident prevention in connection with handling of material is evidence of progressiveness. It also indicates recognition of the necessity for selecting and applying a remedy along well-planned lines, in order to promote safety in the operations associated with work of this particular kind.

Mechanical Hazards Have Been Reduced.—A few years ago, it was considered that unguarded machines and unprotected

[1] See Appendix III, "A Message to Foremen."

mechanical exposures were the chief factors in causing industrial accidents. Conditions have changed, however, and although machines still cause accidents, machine-guard manufacturers and employers who purchase machines and put them to use, working cooperatively, have materially reduced the hazards and incidentally the accidents resulting from these hazards, which exist because of unsafe mechanical or physical conditions. Of all accidents, not more than 10 per cent are fairly attributable to machines, mechanical processes, dangerous liquids, gases, and materials, and to unsafe building conditions, improper dress, lack of safety wearing apparel, lighting, ventilation, and other conditions in the physical or mechanical group of accident causes. On the other hand, 88 per cent of all accidents are now attributed to moral or supervisory failure—to unsafe practices that may be controlled by good management. These unsafe practices include the unsafe handling of material, and it is therefore particularly appropriate at this point to consider ways and means of applying the principles of accident prevention to the business of effecting a remedy for accidents from handling of material.

Two Methods of Accident Prevention.—When interest exists and the pertinent facts of accident occurrences have been found, two highly successful methods may be employed in preventing material-handling accidents. One lies in the study and improvement of methods and procedure[1] to the end that some safer and better way may be found to conduct any particular operation than that in use. The other lies in utilizing that proper degree of supervision—from the chief executives down to the foreman—that will result in the observance and correction of unsafe material-handling practices on the part of the workers, before injuries occur.

Process and Procedure Revision.—That there is opportunity in both fields is apparent. Engineering revision has already substituted mechanical power for man power—mechanical feeding and handling equipment for the slower, more costly, and more dangerous manual handling. Power shovels have been devised of such capacity that one of them will, in a given time, move as

[1] See Chap. VII.

much rock, slag, ore, or other similar material as could be handled by more than 1,000 laborers working with hand shovels, picks, and barrows. Machines have been built that will convert logs to toothpicks and matches, cotton to cloth, and sand to bottles, with no more hand labor than is necessary to adjust, repair, and maintain the equipment.

More encouraging still is the fact that the workers thus released from hand labor have found profitable employment in the constantly increasing operations that have resulted from the public demand for manufactured products—a demand that has been created by the reduction of costs and the betterment of the product through improved mechanical methods of manufacture.

Supervisory Methods.—If engineering revision fails to provide an answer to the problem of preventing handling-of-material accidents, dependence can safely be placed upon ordinary supervisory methods—provided these methods are extended in the direction of safety with the same thoroughness with which they are applied to production.

A careful worker can handle material safely. Even rough and splintered lumber, sharp-edged objects of all kinds, and heavy and cumbersome pieces can be handled without accidents, if the worker is safety-conscious, that is, if he is careful and attentive, gets a good firm grip on the material, and does not let it slip out of his hands. If employees were to ruin expensive products or jam and break tools, dies, and other costly machinery and thus cause unnecessary delay and loss because of their fumbling and bungling—if they were doing these things as frequently as they do the unsafe things that result in handling-of-material accidents—industrial executives would not be at a loss to provide a remedy.

The remedy that they would apply is the one here advocated for safety, namely, supervisory methods based on facts. The foreman would be held responsible for issuing and enforcing orders for careful procedure, and all executives would share in this responsibility.

All that is required is executive recognition and interest, followed by supervisory pressure directed at the causes of the chief sources of trouble, be they encountered in storing or taking down material in racks, in piling lumber, in feeding machines, or in any one of the other countless operations associated with the handling of materials.

The experience of accident-prevention engineers proves conclusively that remarkable results can be attained in this way and that they are being attained wherever the facts are presented to interested executives who are desirous of cooperating and who have the authority and the will to achieve.

Suggested Procedure.—The executives of industry should therefore give due consideration to the following suggestions in their effort to reduce the frequency (and, incidentally, the cost) of handling-of-material accidents. They should:

1. Determine from an analysis of past injuries, the kind of operation conducted, the type of accidents, and the specific causes of the accidents.
2. Analyze existing operations to determine if they are conducted in an unsafe way.
3. Determine the frequency as well as the number of injuries, by operation, location, and by foreman.
4. Study the entire situation carefully and select the place or places and the operations most worthy of attack.
5. Having determined the types of accidents and the specific unsafe practices and conditions at fault, proceed first with engineering revision—asking the question: "Can this operation be done in another, safer, and better manner?"

Note.—The importance of this point should not be overlooked. Consider the case of a manufacturer of small sheet-metal parts who was troubled greatly with a high frequency of cuts from sharp-edged plate stock. Upon investigation he discovered that he could change over to a die-cast product, with a resultant saving in cost, a better product, and fewer accidents.

6. Proceed next (or coincidentally) with improvement of supervision directed to the elimination, or at least the mitigation, of the predominating unsafe practices or conditions in handling of material.

   a. Charge executives with responsibility for the occurrence of accidents.
   b. Enforce instructions as to safe-handling practices.
   c. Keep in mind that an unsafe act occurs several hundred times before a serious injury results and that there is, therefore, an excellent opportunity to detect and correct unsafe practices before injury occurs.
   d. Select, train, and instruct employees.
   e. Place accident prevention on a par with production, with respect to supervisory methods of improvement and executive interest, participation, and follow-through.

Executives who follow this procedure will have the satisfaction of knowing that they are progressing along well-founded, practical, and effective lines. They may, moreover, be reasonably assured of favorable results that will save money for the establishments that they represent; and, best of all, they will save human beings from the suffering that ordinarily follows the occurrence of industrial accidents resulting from the handling of material.

CHAPTER VI

MACHINE, PRIME-MOVER, AND POWER-TRANSMISSION GUARDING

Although man failure in its several specific forms is justifiably indicated as the major cause of industrial accidents, it is nevertheless axiomatic that reasonably safe mechanical and physical environment is a prerequisite and continuing function in accident prevention. No matter how strongly the statistical records emphasize personal faults or how imperatively the need for educational activity is shown, no safety procedure is complete or satisfactory that does not provide for the guarding of machines, the provision of safe tools, adequate light, ventilation, and sanitation and for the correction or elimination of other mechanical and physical hazards.

In these days of advanced engineering practice there are few machines or mechanical processes that cannot be made almost wholly safe. However, such matters as exorbitant expense, interference with production, space or time requirements, and magnitude of the effect in the safety problem require consideration. Such consideration in rare cases may result in negative action. Practicality and common sense can be relied on to govern decisions, especially when these are tempered by a sincere desire to protect human life and limb.

"Fact Finding," as outlined in Chap. IV, can be depended on also to show the *degree of importance* that should be attached to machine guarding as compared to the prevention of personal unsafe acts, but in no case should the former be overlooked. In addition, it is well to bear in mind that production is vitally affected by the occurrence of personal injuries and that expense and other objections to safe guarding often turn out to be more apparent than real.

The purpose of this chapter is to point out the relative importance of mechanical guarding, to describe the fundamentals of guarding procedures, and to illustrate methods of application.

Referring specifically to machines, the hazards to employees who operate and maintain them arise from the point-of-operation and from belts and pulleys, gears, projecting parts, shaft ends, clutches, and other moving parts. Guards for the point-of-operation and the dangerous moving parts of the machine proper (excluding the driving belts or other driving mechanisms when the latter are not provided as a unit with the machine) may be designed and applied most advantageously and inexpensively by the builder of the machine. This usually means that the machine itself is designed so as to facilitate guarding and that the guards are incorporated as an integral part of the entire unit. In other words, the designer and draftsmen make one job of both the machine and its guards. The guards fit better and are more rigidly attached. There is no necessity for weakening the machine structure, as might be the case if the guarding were to be done by others. Bosses or extensions for the attachment of covers and hoods may be cast with the frame or body of the machine. From all points of view, the ideal situation is one where individual machines are designed with due regard for safety principles and are manufactured and delivered to the purchaser by the manufacturer, in as fully guarded a condition as practicable.

The ideal, however, has not yet been attained, although many manufacturers of machines build guards on and into the equipment they produce. The machine-tool field provides a striking example of progress of this kind. Lathes, milling machines, shapers, planers, drills, and other machines are placed on the market with gears and other dangerous moving parts fully guarded. In some cases, guards are also provided by the machine manufacturer for the cutting or working tools (points-of-operation). The same situation exists in varying degrees in connection with the manufacture of boots and shoes and in the textile, food, woodworking, and other industries. There is, however, a long way to go before it can be said that the practice of providing guards as a part of the process of machine manufacture is practically universal. This is particularly true with respect to protection at the working point, or the point-of-operation, of machines.

It is highly fortunate, therefore, that certain individuals and organizations are now specializing, with much success, in the design, manufacture, and installation of guards. There is a vast field of usefulness here, and regardless of progress in the direction of original design and installation of guards by the manufacturers of machines, there will probably always be a heavy demand for the products of independent guard manufacturers.

POINT-OF-OPERATION GUARDS

The purpose of point-of-operation guarding is to prevent injury to the operator at the part of the machine where the work of shaping, forming, cutting, blanking, shearing, squeezing, drawing, or manipulating the stock in any other way is actually done. Safety at the point-of-operation may be accomplished in one or more of the ways indicated in the following list.

A. Designing and constructing tools so that guards are not required.
B. Providing inclosures, covers, and barricades.
C. Providing mechanical feeding devices.
D. Providing devices that prevent or interrupt the movement of tools when the operators' hands are in the danger zone.
E. Providing remote-control operating mechanisms.
F. Providing mechanical devices that remove the hands from the danger zone.

Broadly interpreted, these devices may be said to include in their scope of application practically all the many methods of point-of-operation guarding now in use or that may be made use of in the future. One or more of them may be applied on the same machine and at the same time. In addition to these groups of guards there are what may be called "incidental devices" to point-of-operation guarding, such as emergency or safety stops and nonrepeat mechanisms. It is difficult to achieve perfection in safeguarding machines at the point-of-operation, but commendable progress is being made. Striking examples are found in the guards that have been devised for metalworking, woodworking, leather, laundry, food, paper-box and paper, foundry, textile, and rubber machines and, in varying degrees, in practically all industrial lines.

Complete analysis and exposition of point-of-operation guarding are beyond the scope of this work. It is likewise not intended that the guards shown in the accompanying figures shall necessarily represent ideal or complete protection. The examples given are merely for the purpose of portraying visually the particular principle of point-of-operation guarding that is thus emphasized. The principles or fundamentals, however, as indicated by the foregoing list of devices, will be commented upon and illustrated, each in turn.

Group A. Designing and Constructing Tools So That Guards Are Not Required.—Design of tools for the purpose of eliminating (or, at least, minimizing) the danger of injury at the point-of-operation is not, strictly speaking, a part of guarding, but its objective is similar, and, therefore, it is appropriate to refer to it here.

In the work of eliminating injuries at the point-of-operation of machines, one of the most effective, and, in some cases, one of the most practical remedies, is so to design the tools that they will give rise to no danger and, consequently, no necessity for guards. For example, if the operation of forming, shearing, or stamping small metal objects is performed inside the body of the tool (the blanks or stock being inserted through an opening that is too small to permit the entry of the fingers or the hand), the operation may be termed practically safe and reasonably foolproof. The many self-contained dies and subpress tools used in punch-press work are good examples of this design (see Fig. 15). Also the short-stroke stamping press (see Fig. 16) is an example of safe tool design. The ram of a corner stayer (see Fig. 17) has been so designed that its action is not positive until it is so close to the anvil that the fingers of the operator cannot be inserted and injured. Although the circular head of a jointer or buzz planer does not wholly eliminate the possibility of injury (there is no known method of assuring absolute freedom from hand cuts caused by jointer heads), it greatly minimizes the severity of any injury that may occur. The knives on a circular head project but a short distance beyond the periphery of the head, as compared with those on a square head and thus (without interference with speed or quantity of production) limit the depth of the cut, not only as far as the stock is concerned but also with respect to a workman's hand, in case he inadvertently thrusts it into the opening in the jointer table while the head is revolving (see Fig. 18).

For greater safety, cover or inclosure type guards are commonly used with circular heads, as well as with square heads.

The pencil sharpener shown in Fig. 19 provides a homely and readily understood example of how tool design may result in safe operation.

A circular-saw blade has been devised that has a novel safe arrangement of teeth (see Fig. 20). Each cutting tooth is preceded by a blunt-nosed safety tooth that limits the depth of the cut with no decrease of production. Injury is not wholly

FIG. 15.—A self-contained subpress die. (*Courtesy of the Waltham Machine Works.*)

This tool is complete within itself. The space is so reduced between the punch and die that there is little opportunity for injury at the point-of-operation.

prevented, but the probable severity of the injury in case of accidental contact is minimized.

Dies on presses may be so designed that many unnecessary handling operations are eliminated, thus reducing the probability of injury. The dies may be so arranged that the piece after blanking is carried automatically to the piercing, forming, swaging, or drawing dies on the same machine and there completed without rehandling. Such tools, where more than one operation is performed at a single stroke of the press, are sometimes called "transfer" or "progressive dies" or are referred to as "multiple tools" or as "two," "three," "four," or more "step dies" (see Figs. 21, 22).

These are but a few of a vast number of ways in which the point-of-operation of machines may be made comparatively safe by removing the hazard when the tool is designed, but they serve to illustrate the assertion that safe tool design is a fundamental in point-of-operation guarding.

Fig. 16.—A self-contained punch and die on a short-stroke blanking press. (*Courtesy of The J. M. Ney Company.*)

The stroke of the press ram is approximately ⅜ inch, and the dies are of the subpress variety.

FIG. 17.—Safety device for a paper-box corner stayer. (*Courtesy of The M. D. Knowlton Company.*)

When the descending ram *R* encounters the fingers of the operator or other resistance before it reaches a point $\frac{5}{32}$ inch from the anvil *A*, the safety device *S* will collapse, the descent of the ram will be interrupted and further harmful pressure will be prevented.

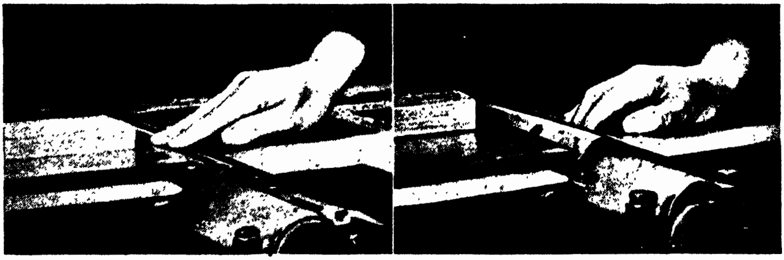
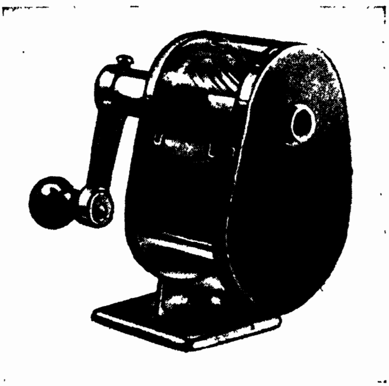


FIG. 18.—Jointers with circular and square heads. (*Courtesy of The Hartford Builders Finish Company, Inc.*)

The illustration at the left shows how the circular head prevents the fingers of the operator from entering the opening in the table to such an extent as to permit amputation. At the right the square head permits the fingers to extend well below the top of the table.



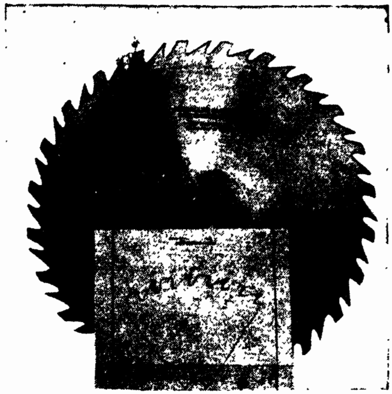


FIG. 19. FIG. 20.

FIG. 19.—Pencil sharpener with complete inclosure.

If the principle displayed in the design of this pencil sharpener were more generally applied to dangerous power-driven machines, the frequency of machine accidents would be greatly reduced. The cutters are fully inclosed. There is an opening of sufficient size for the pencil to enter.

FIG. 20.—Safety circular saw. (*Courtesy of J. H. Dubrule.*)

The alternately arranged safety teeth of this circular saw blade prevent kickbacks. The safety teeth are relieved slightly below the cutting edge of the cutting teeth; also they are not set at an angle. Dropping a piece of lumber on the saw fails to produce a kickback. Although there is no interference with speed of production, the safety teeth limit the depth of the cut at one revolution of the saw and thus decrease the probability of amputation should the fingers of the operator come in accidental contact with the saw.

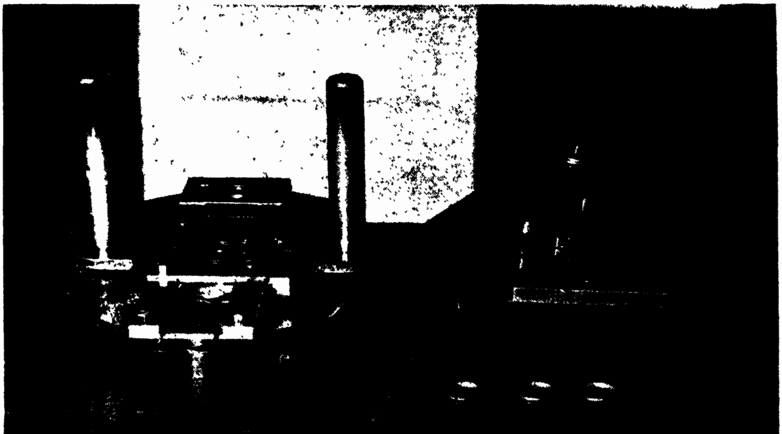


FIG. 21.—Three-step four-operation punch and die. (*Courtesy of the Underwood Computing Machine Division of the Underwood Elliot-Fisher Company.*)

Strip stock is inserted in the guide at one end. As the stock is fed by hand, four operations are performed: (1) piercing, (2) blanking, (3, 4) forming and piercing. The product in the foreground shows the kind of work done.

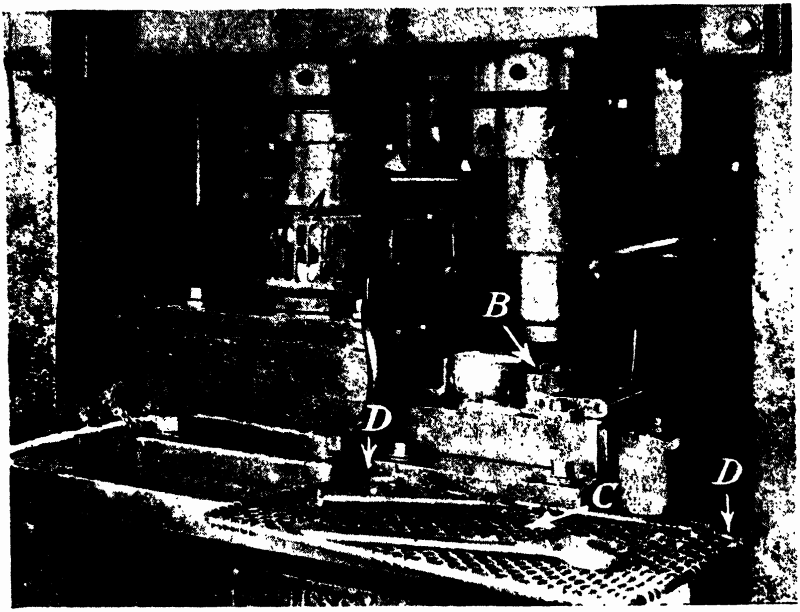


FIG. 22.—Transfer blanking and drawing dies. (*Courtesy of the E. W. Bliss Company.*)

The punch and die *A* make the blank and perform the first drawing operation at one stroke. By means of a special sliding carrier the formed shell is then passed to die *B* where the final redrawing operation is performed. The production rate is 1,400 per hour. The wire-screen guard *C*, for protecting the die *B* when the press is in use, has been thrown forward to show the second operation. This guard is normally held in its vertical position by springs *D* and *D*.

Group B. Providing Inclosures, Covers, and Barricades.—Point-of-operation guards comprise many varieties of inclosures, covers, or barricades which are placed around the working tool itself, as distinguished from the entire machine of which the tool is a part. The inclosure is one of the simplest, least expensive, and most effective of all point-of-operation guards and in one of its many forms may be applied to a great variety of machine tools and operations. Solid sheet metal, transparent plastic, fiber board, nonshatterable glass, perforated or expanded metal, wires or wire mesh may be placed about punch-press tools (see Fig. 23) in blanking or piercing operations, and in many kinds of forming work, leaving room only for the insertion of strip stock or flat pieces. Removal of the guard is necessary before the operator can get his hands between the dies and in the danger zone. Openings in the inclosure make it possible to brush the tools with oil and to insert a small rod to remove blanks or piercings.

The ordinary type of circular-saw hood guard is another kind of inclosure. One of the well-known types of guards rests on the table when there is no stock beneath it and adjusts its lift auto-

Fig. 23.—A plunger inclosure guard for a stamping press. (*Courtesy of the National Conservation Bureau.*)

The opening in the front through which the stock is fed is not large enough to permit entry of the operator's hands. The wires in the inclosure are placed vertically so that the motion of the punch as it travels up and down does not tire the eyes of the operator.

matically to the thickness of the work, thus covering the teeth of the saw at all times (see Fig. 24). Some of the great number of other types of inclosure or hood guards for circular saws are also shown (see Figs. 25, 26, 27).

Inclosures or hoods are applicable to grinding wheels (see Figs. 28, 29), and guards of the inclosure, cover, or hood variety are adaptable to certain machines in practically every industry (see Figs. 30, 31, 32, 33, 34, 35, 36, 37, 38).

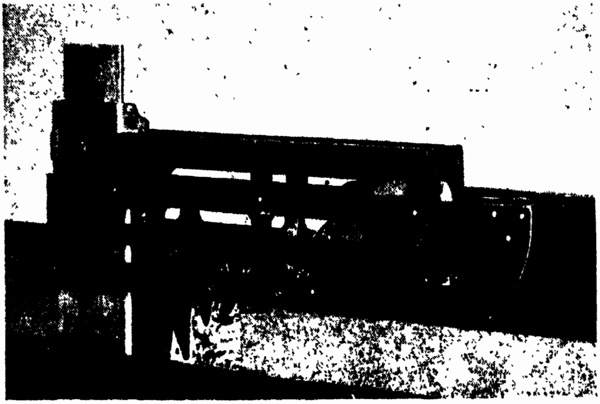


FIG. 24.—Rip saw showing guard attached to the spreader. (*Courtesy of The French Automatic Safety Devices.*)

The hood is hung from a horizontal bar, upon two parallel pivot arms which allow it to swing backward and upward to accommodate variations in the thickness of stock. If a kick-back occurs, the guard acts as a clamp and wedges the stock firmly against the table.

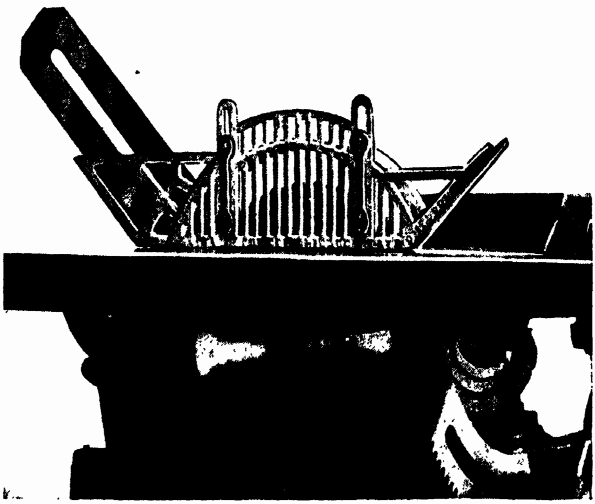


FIG. 25.—Table saw set up for crosscutting operations. (*Courtesy of The Surty Manufacturing Company, Inc.*)

The aluminum guard or hood is supported by an inclined spreader. The hood slides in the direction of the slot in the spreader when stock is fed to the saw. Nonkickback fingers are provided on the other side.

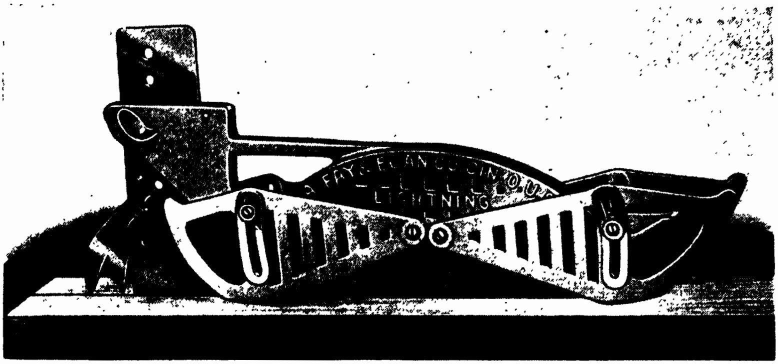


FIG. 26.—A circular saw guard showing hood, spreader, and nonkickback device. (*Courtesy of the J. A. Fay & Egan Company.*)

The entire mechanism is supported by a throat piece and is easily installed.

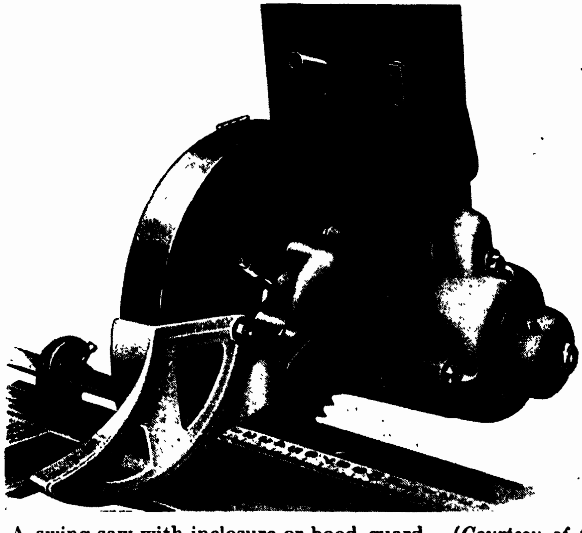


FIG. 27.—A swing saw with inclosure or hood guard. (*Courtesy of the Oliver Machinery Company.*)

This machine is driven by an individual motor, and a control switch is conveniently located. The upper half of the saw is inclosed. The aluminum front shield is pivoted at its heel and is free to ride over the stock as the saw is pulled forward.

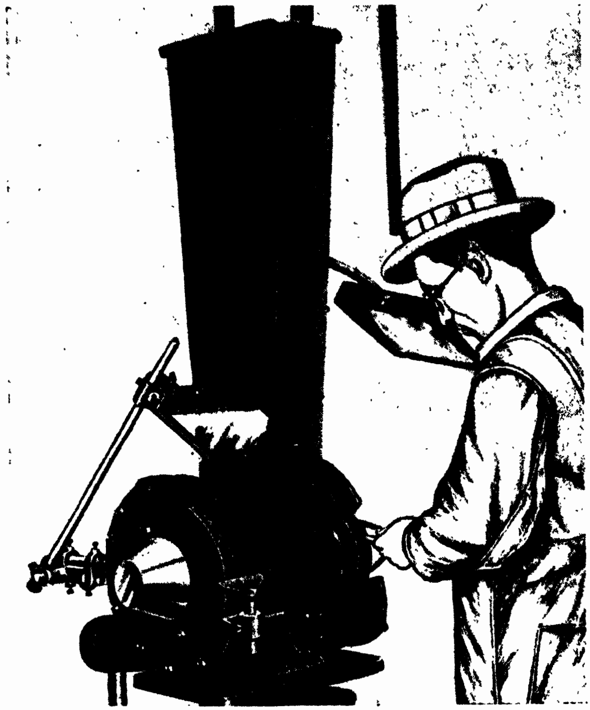


FIG. 28.—Multiple guarding of grinding wheels. (*Courtesy of the Surty Manufacturing Company, Inc.*)

The hoods are adjustable, the arbor ends are covered, the drive belt and pulley are protected, and adjustable glass eye shields are also provided.

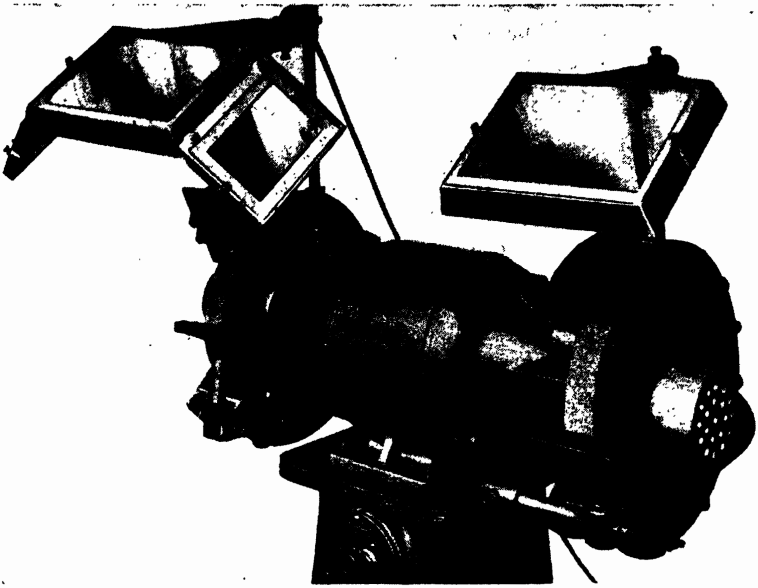


FIG. 29.—An individually driven twin-wheel grinding unit. (*Courtesy of the Surty Manufacturing Company, Inc.*)

Substantial hoods or inclosures, arbor-end covers, and glass shields are provided. Motor-control buttons are conveniently placed.

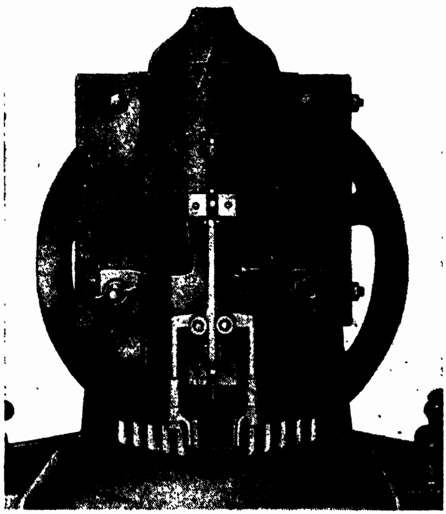


FIG. 30.—A barrier guard on a corner cutter. (***Courtesy, John T. Robinson Co.***)

As the stock is fed to the machine it strikes the cup-shaped piece at the bottom of the guard and causes it to rise. The guard remains in contact with the stock and leaves no room for the insertion of the operator's fingers.

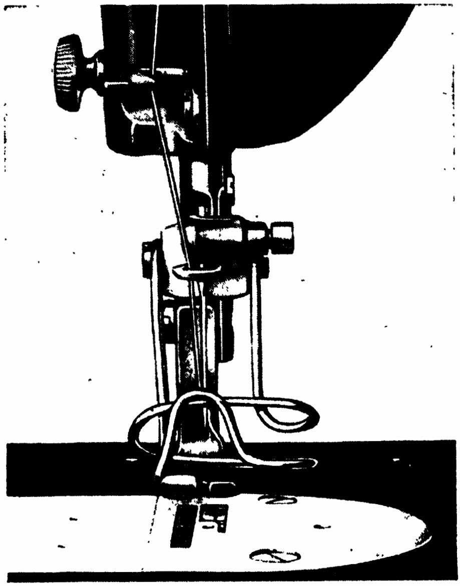


FIG. 31.—A sewing machine with barrier guard for the needle. (*Courtesy of the Singer Sewing Machine Company.*)

A good example of barrier guarding is here shown as applied to the point-of-operation of a sewing machine.

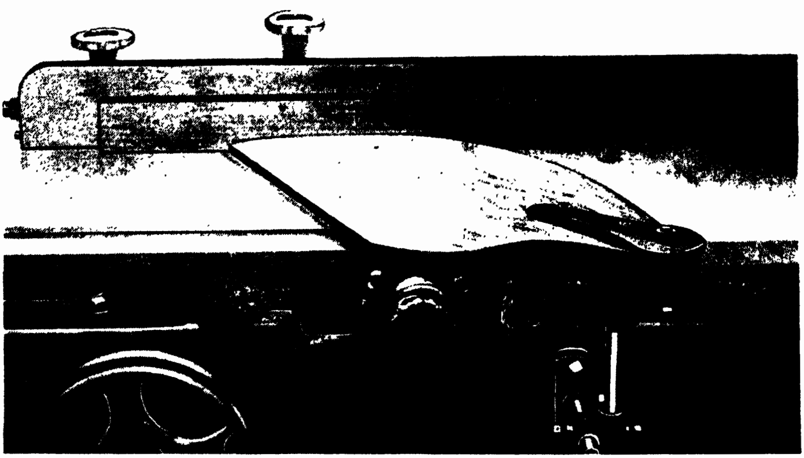


FIG. 32.—A jointer or wood buzz planer with table guard. (*Courtesy of the Bison Machine Company.*)

The horizontal cover guard is pivoted. It protects the portion of the cutting cylinder not in use and swings to its closed position after the stock being planed has passed through. Circular safety heads are commonly provided in addition to the table or cover guards shown here.

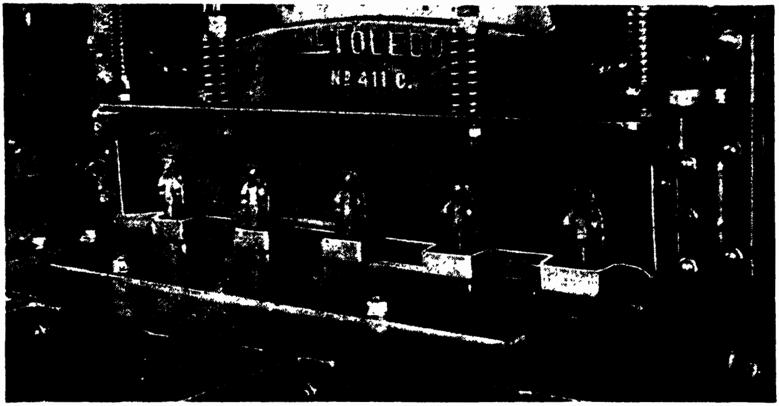


FIG. 33.—A power squaring shear with a homemade barrier guard for the blade and presser foot lugs. (*Courtesy of the Westinghouse Electric & Manufacturing Company.*)

The opening between the lower edge of the guard and the machine table is but ⅜ inch.

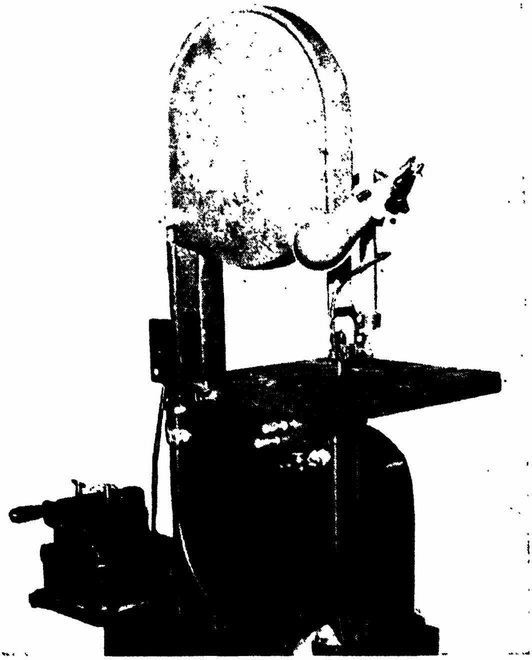


FIG. 34.—Band saw with inclosure and barrier guards. (*Courtesy of the National Conservation Bureau.*)

The guards for both upper and lower wheels have extensions that cover practically the entire length of the saw blade. An adjustable point-of-operation barrier guard and blade guide is also provided.

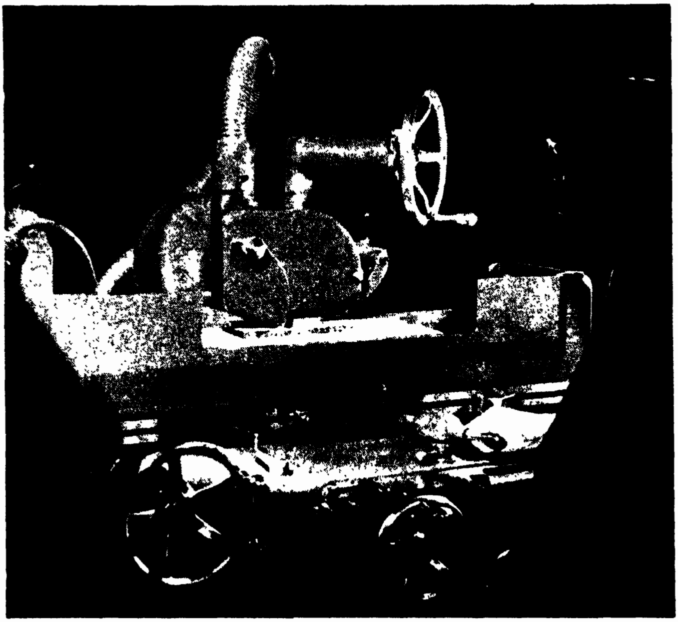


FIG. 35.—Surface grinder with inclosure guard and exhaust system. (*Courtesy of the Norton Company.*)

The design of this machine and of its guards and exhaust attachments fits the expression "streamlined." This figure also illustrates the combining of several forms of guarding. Note the individual drive, hood for the wheel, and safe contouring.

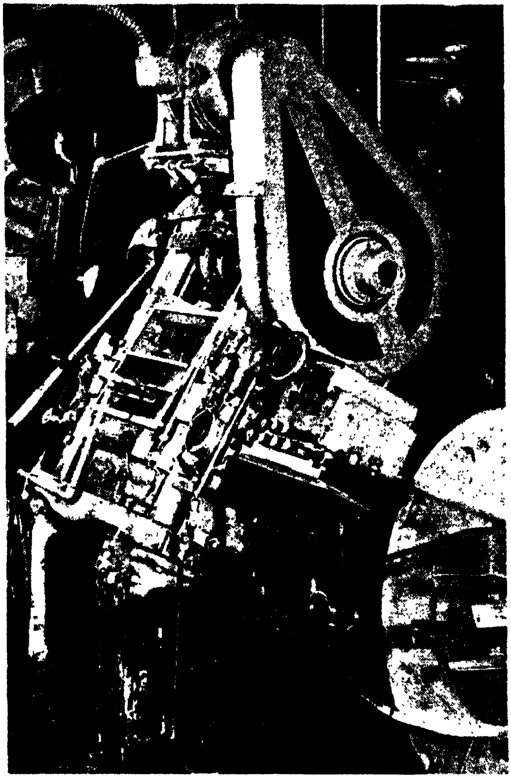


FIG. 36.—Roll-fed stamping press with plunger inclosure.

The plunger inclosure is but one of several safety features on this machine. The automatic roll feed also guards the point-of-operation. This figure also illustrates machine guarding other than at the point-of-operation. Note the excellent flywheel guard and the individual motor drive.

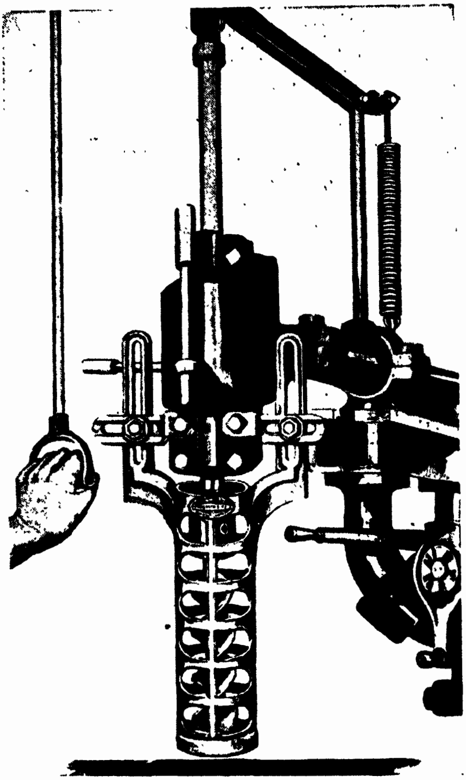


FIG. 37.—Vertical wood-boring machine with inclosure for the bit. (*Courtesy of L. F. Grammes & Sons, Inc.*)

A perforated tube-shaped inclosure has been placed around the bit. The lower end of the guard is adjusted so that there is room only for the stock between the guard and the table.

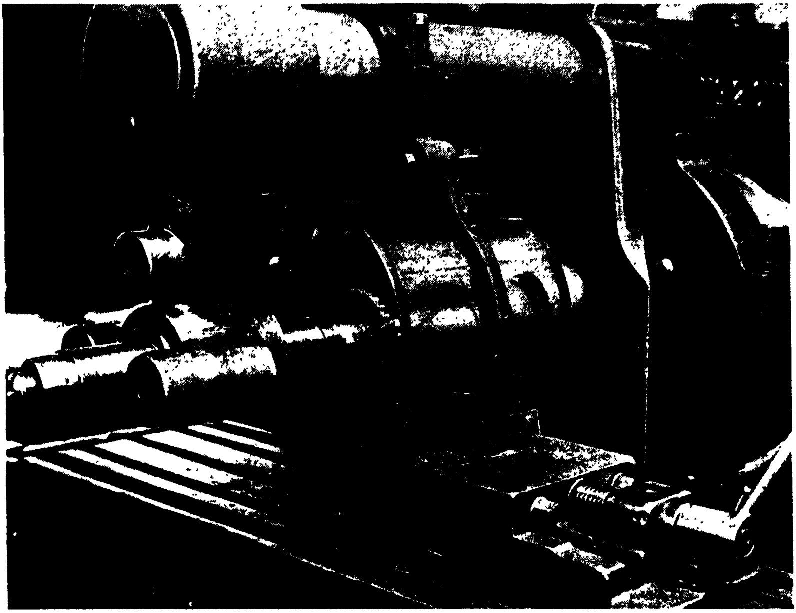


FIG. 38.—Milling machine with inclosure guard for the cutter. (*Courtesy of the Westinghouse Electric & Manufacturing Company.*)

The guard is transparent so that a view of the work may be obtained. It is also hinged at the top to facilitate access to the work.

Group C. Providing Mechanical Feeding Devices.—As far as mechanical feeding devices protect the machine operator from injury resulting from contact with the parts of the working tools that perform blanking, shearing, forming, cutting, or other operations, they may be included with other point-of-operation guards. Many ingenious mechanisms have been devised to supplant hand-feed methods with resulting increase in production, decrease of spoilage through uniformity in handling, saving in production cost, and, best of all, materially less danger to employees. The desire to attain these ends has been the incentive for study, experimentation, and invention.

Various means and methods are utilized in mechanical feeding, including rolls, gears, dials, chutes, hoppers, magazines, slides, air pressure or vacuum, gravity, friction, springs, electric current, steam, hydraulic pressure, gravity flow of liquids, and many combinations of these and other means (see Fig. 39).

The chief safety function of mechanical-feeding devices is to make it unnecessary for the operator to place his hands or any other part of his body within the point-of-operation danger zone. The mechanical feed alone does not eliminate all danger, however. An unguarded punch press of the type ordinarily used for blanking, even though it is equipped with a full automatic roll

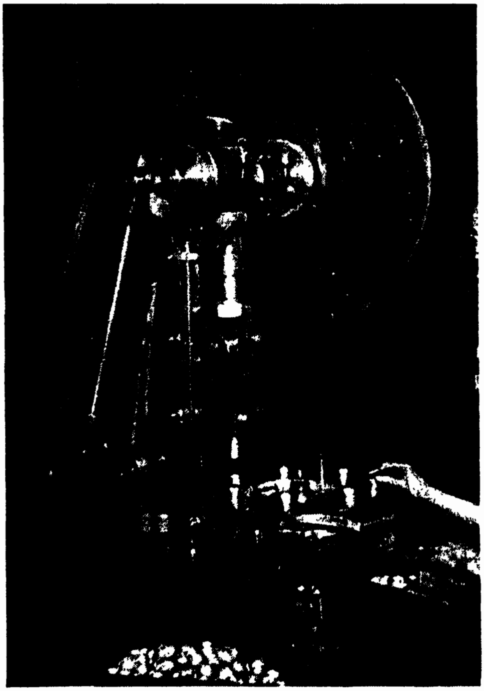


Fig. 39.—Dial feed on a forming press.

The operator loads the revolving dial at a safe distance from the point-of-operation, and the dial carries the stock under the punch where the forming work is done.

feed, is not wholly safe. More complete protection is afforded when an inclosure guard is also installed and when the feed rolls are guarded on the inrunning side (see Fig. 36). It is entirely unnecessary for the operator of a roll-fed press to insert stock directly between the dies or to place his hands in the danger zone for any other reason, while the machine is in operation. The roll feed does not actually *prevent* him from doing so, however. Safer practice calls for supplementing mechanical feeding by some form of inclosure or other protection.

Gravity feed is a simple and inexpensive means of avoiding danger at the point-of-operation of machines. Vertical or inclined-gravity slide feeds are readily adapted to punch-press work (see Figs. 40, 41), to automatic lathes (see Fig. 42), and to a great variety of other machines. A combination of gravity and forced-slide feed may also be employed. There are many other types of feed devices, all of which make use of gravity (see Figs. 43, 44).

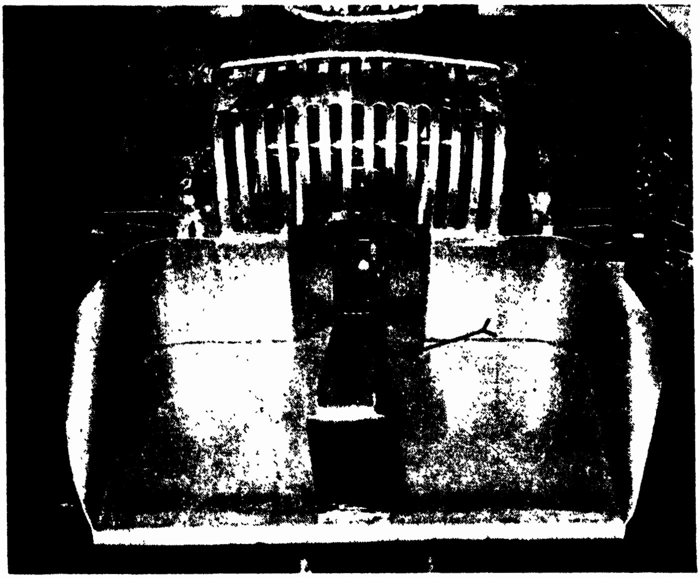


FIG. 40.—A slide feed plus inclosure on a power press. (*Courtesy of the National Conservation Bureau.*)

Stock is placed on the inclined slide shown by the arrow. It slides by gravity to position under the punch. The inclosure further safeguards the point-of-operation.

A person who observes, perhaps for the first time, the action of the mechanical-feed device for a job printing press may marvel at the almost human facility with which it handles the work to and from the machine. Devices of this type make use of positive mechanical action plus vacuum (see Fig. 45).

The principle of magnetism is sometimes usefully applied in replacing hand feed by mechanical methods. More commonly, however, this principle is applied in the handling of ferrous metals during operations that do not necessarily require machine feeding (see Figs. 46, 47, 48).

The mechanical conveyor is adaptable to a wide variety of needs in the feeding of machines. Endless-belt conveyors are used for carrying raw material to rag cutters (see Fig. 49) carding machines (see Fig. 50) band resaws (see Fig. 51) and many other machines.

A familiar example of screw-slide feed is found in machines used for slicing bread and meat (see Fig. 52).

In the textile industry, air pressure is used to blow cotton from the pickers to the carding machine. The same principle is utilized in the cotton gin (see Fig. 53).

In some instances the normal functioning of the machine itself draws stock as required without feed rolls, gears, conveyors, or other separate mechanical feeding mechanism (see Fig. 54).

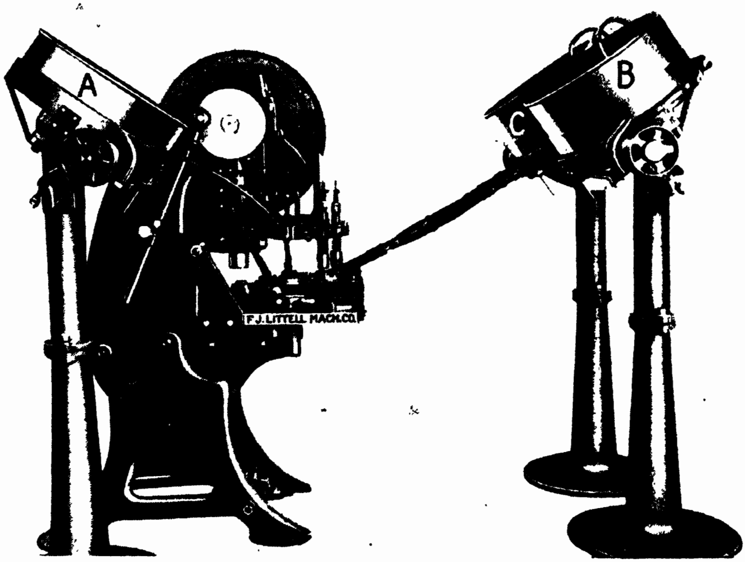


FIG. 41.—Punch press equipped with gravity slide feed. (*Courtesy of the F. J. Littell Machine Company.*)

This machine is used to assemble casters. Shells are placed in hoppers *B* and *C* and spindles in hopper *A*. The parts slide down chutes to the dies where they are assembled and the casters automatically ejected.

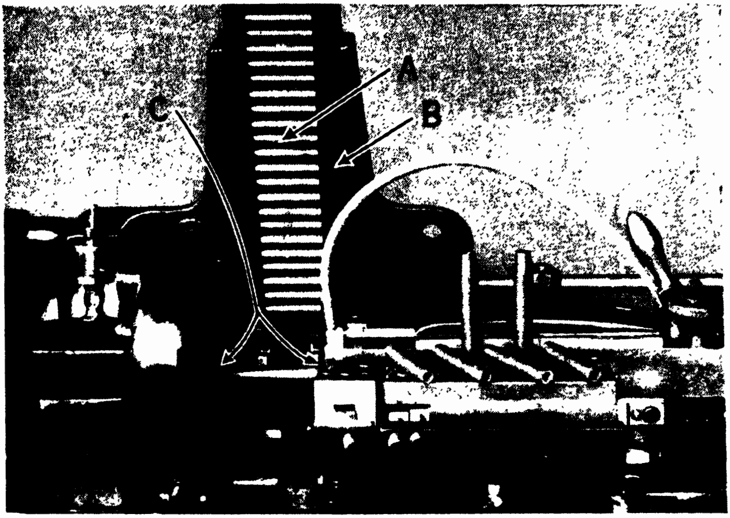


FIG. 42.—Lathe equipped with gravity-slide-feed magazine. (*Courtesy of the Pratt & Whitney Company.*)

The spindles *A* slide down the vertical magazine *B* and are conveyed by mechanical fingers to the chuck *C*. After the operation is performed the work is automatically ejected.

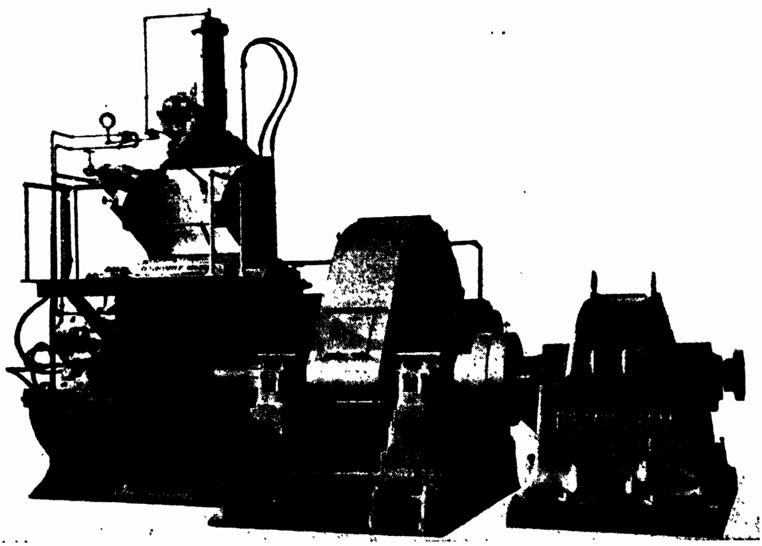


FIG. 43.—Rubber mixing mill employing, in part, the principle of gravity feed. (*Courtesy of the Farrell-Birmingham Company.*)

Material is loaded into the hopper and is free to fall toward the rolls below. The vertical ram above the hopper then completes the feeding operation by pushing the materials into the rolls.

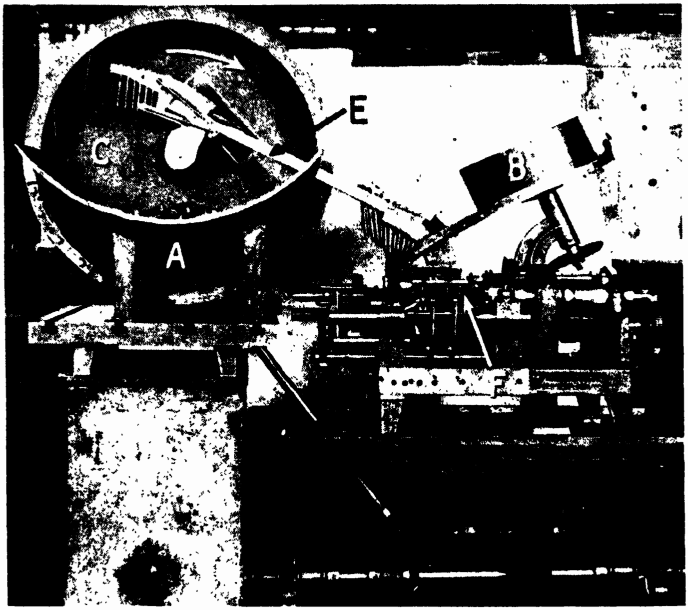


FIG. 44.—Automatic bolt-and-nut assembling machine. (*Courtesy of The Asa S. Cook Company.*)

This is an excellent example of mechanical handling of small bolts in large quantities utilizing a selective disk *C* revolving in a hopper *A* and a gravity slide chute *E* to carry the bolts to the chuck *F*. The nuts are placed in hopper *B* from which they slide to position ready to be assembled. Ejection after assembly is by means of mechanical fingers.

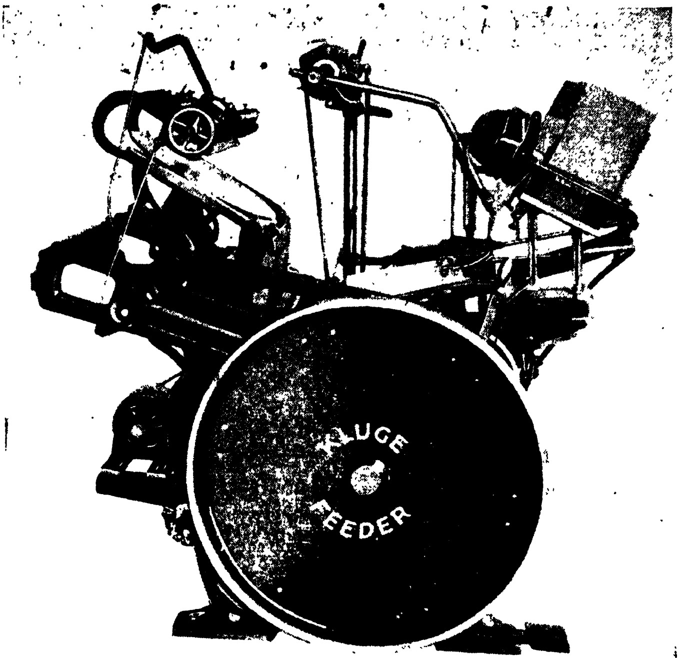


FIG. 45.—Job printing press with mechanical feed. (*Courtesy of Brandtjen and Kluge, Inc.*)

Accurately timed and aligned mechanical fingers provided with vacuum tips on this job printing press seize each sheet of paper in turn and carry it to position on the platen. Other vacuum fingers take the finished sheet away and stack it neatly. The feeding operation thus performed eliminates the necessity for the operator to place his hands between the platen and the chase.

FIG. 46.—Electromagnetic hoist handling red-hot steel ingots. (*Courtesy of the Electric Controller & Manufacturing Company.*)

This 65-inch lifting magnet handles ingots after the molds are stripped off. The magnet takes hold as soon as the corners of the ingots are sufficiently cooled but while certain parts are still red hot.

FIG. 47.—An electromagnet salvaging steel billets from a sunken barge. (*Courtesy of the Electric Controller & Manufacturing Company.*)

FIG. 48.—Handling materials with an electromagnet. (*Courtesy of the Electric Controller & Manufacturing Company.*)

The load shown consists of 29 kegs of 8-penny nails, each keg weighing 100 pounds. Note how good housekeeping is facilitated.

FIG. 49.—Rag cutter with conveyor feed. (*Courtesy of B. F. Perkins and Son, Inc.*)

Rags are carried from and to the cutting machine by the inclined conveyors shown at the right and in the center of the picture.

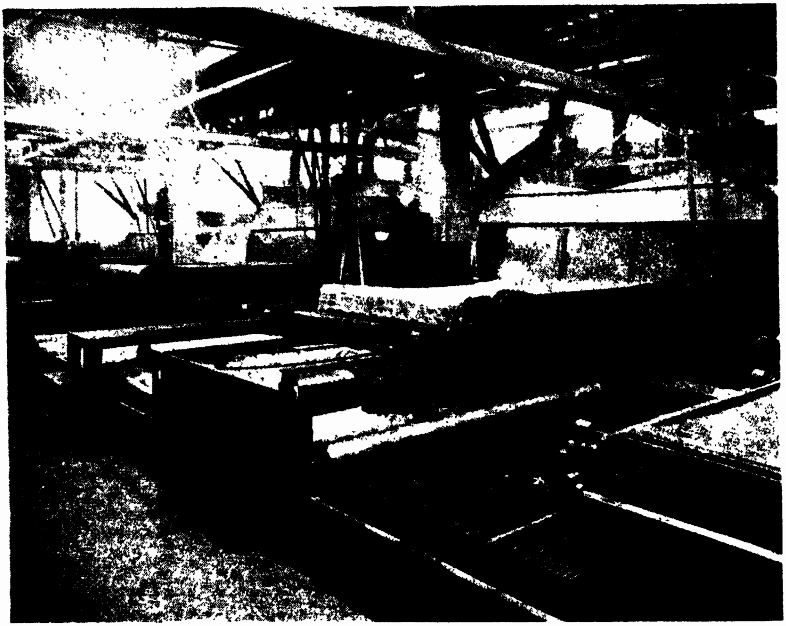


FIG. 50.—A battery of carding machines with mechanical conveyors. (*Courtesy of the Ford Motor Company.*)

A mechanical conveyor acts as a collector on this battery of carding machines which produce felt for padding. The felt is carried to the upholstery department.

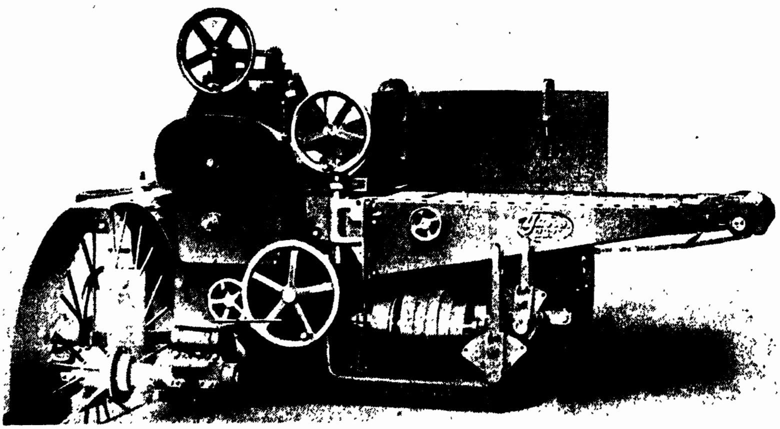


FIG. 51.—A large horizontal band resaw with chain conveyor feed. (*Courtesy of the P. B. Yates Machine Company.*)

The stock is carried by the conveyor feed directly under a barrier to the inrunning side of the feed rolls which force it against the saw blade.

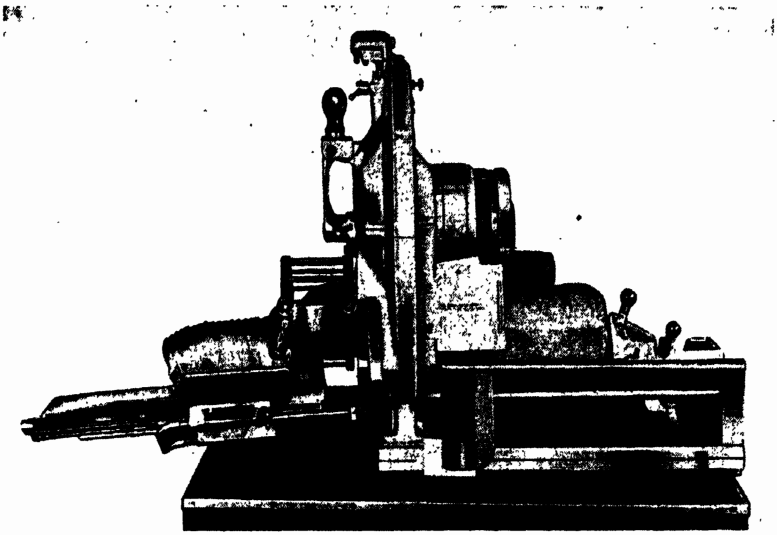


FIG. 52.—An electric bread slicer. (*Courtesy of the U. S. Slicing Machine Company.*)

This machine will slice bread in any one of 19 different thicknesses. All moving parts are properly inclosed.

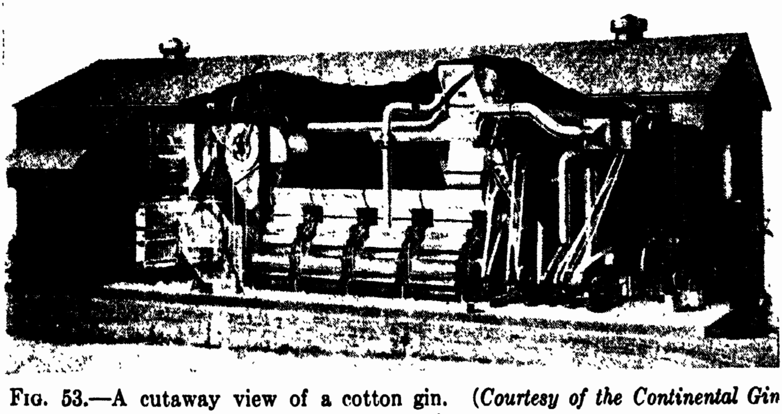


FIG. 53.—A cutaway view of a cotton gin. (*Courtesy of the Continental Gin Company.*)

Note the air ducts that carry the cotton from the customer's vehicle through the separator and into the ginning units. The cotton need not be touched by hand from the time it is sucked up from the vehicle until it comes out in finished bales.

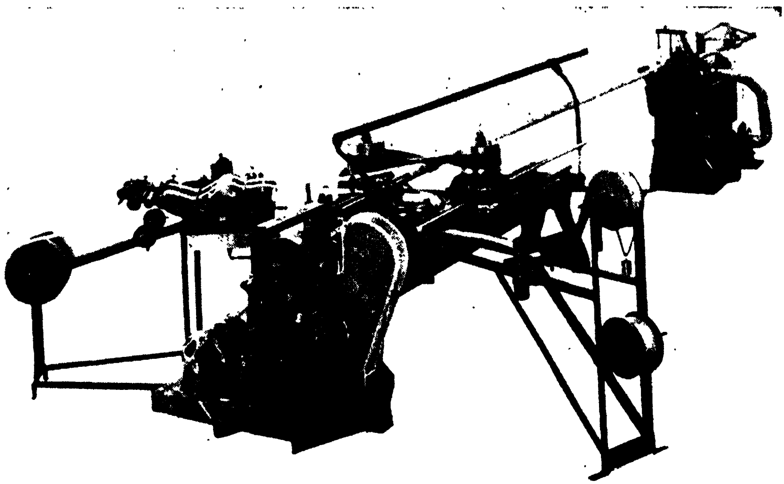


Fig. 54.—Spiral paper-tube machine with full automatic feed. (*Courtesy of the M. D. Knowlton Company.*)

After the initial threading operation required when the machine is set up, the action of the machine draws the paper from reels, winds it spirally into tubes, glues it together, and cuts it to the desired lengths without hand feeding.

Group D. Providing Devices That Prevent or Interrupt the Movement of Tools When the Operator's Hands Are in the Danger Zone.—A good example of point-of-operation protection through interruption of the tool movement when the hands are in the danger zone is the job-printing-press guard (see Fig. 55).

Gate guards may be arranged so as to cut off the power and stop the motion of the machine almost instantaneously if the operator's hands are placed in a dangerous position (see Fig. 56).

The photoelectric cell (electric eye) is readily applied to the operating mechanism of power tools. The cells can be so placed that the interruption of the beam will prevent starting or further movement (see Fig. 57).

A large number of other devices (see Figs. 58, 59, 60, 61) are arranged in such a way that the tool cannot be set in motion or, if in motion, will be stopped unless the hands are wholly withdrawn from the danger region. These include gates and covers that interlock with starting and stopping mechanisms, platforms that prevent operation when a person stands on them and devices that must be moved before the operator of a machine can put his hands in the danger zone.

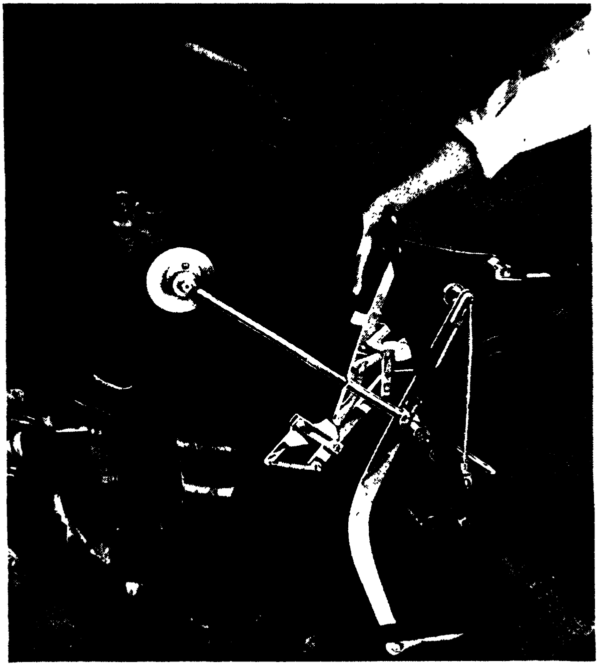


FIG. 55.—Job-printing-press platen guard. (*Courtesy, The Travelers Insurance Co.*)

An eccentric is secured to either end of the back shaft, and the two side arms that actuate the platen are mounted on these eccentrics. The closing motion of the platen is preceded by a steel band and if contact is made with the steel band, it rotates the eccentrics so that further closing motion of the platen is prevented.

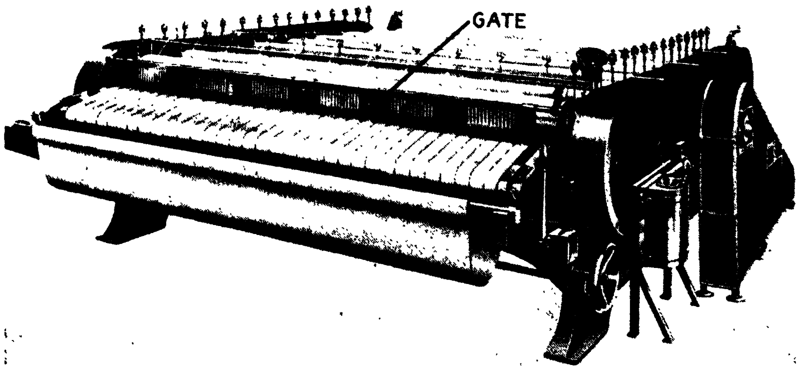


FIG. 56.—A flat-work ironer equipped with a pivoted and electrically contacted gate guard. (***Courtesy of the Troy Laundry Machinery Company, Inc.***)

If the operator's hand strikes against the gate, which runs the full length of the intake roll, the gate will swing upon its pivot, break the electrical circuit to the driving motor,

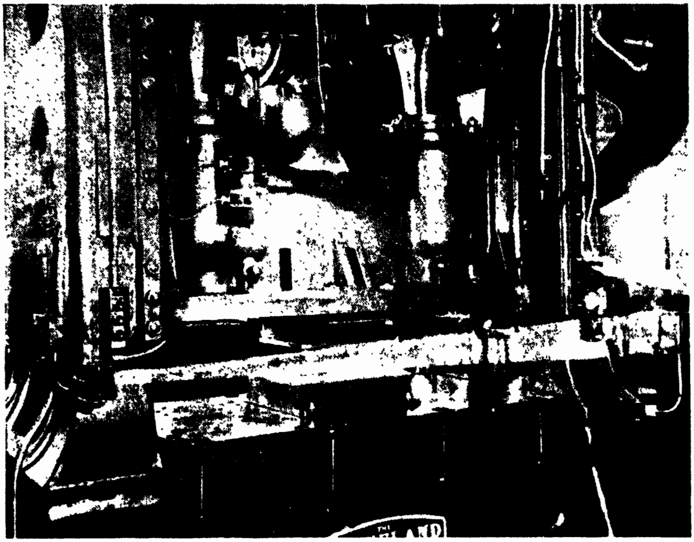


FIG. 57.—An "electric-eye" (phototube) control. (*Courtesy of General Electric Company.*)

A modern application of the photoelectric cell. The press cannot be operated when any part of the body or other object obstructs the ray of light.

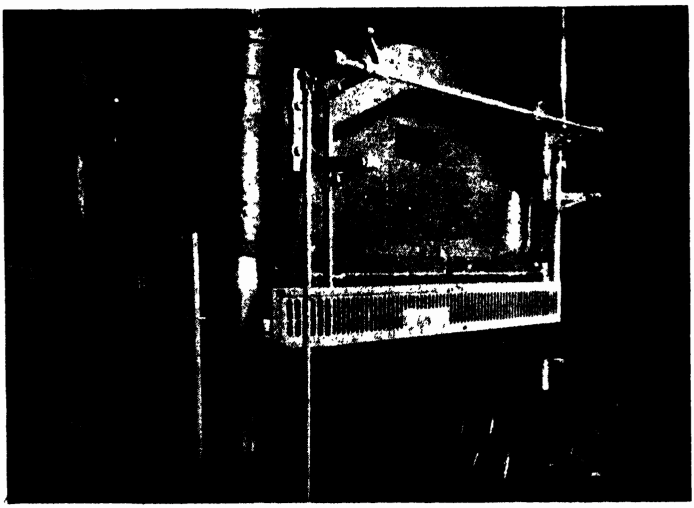


FIG. 58.—Embossing press guard. (***Courtesy of The Travelers Insurance Company.***)

Vertical sliding gates block entry to the point-of-operation from both front and rear. In addition there are fixed inclosure guards at both ends of the press. Any obstruction that prevents the vertical sliding gates from closing to a predetermined position will shut the machine off so that injurious pressure cannot be applied. A pressure of only a few ounces against the operator's hand is sufficient.

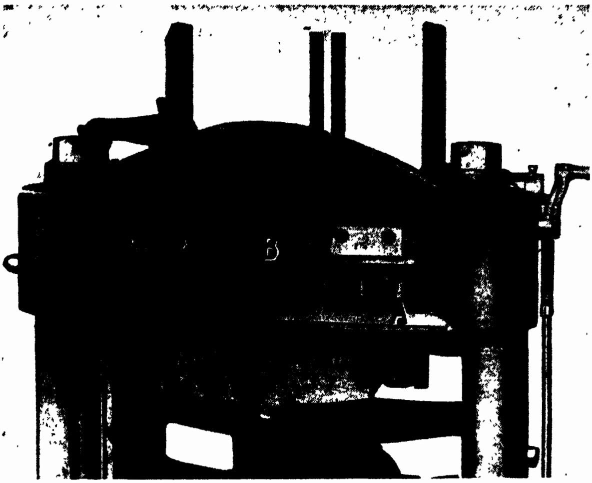


FIG. 59.—Box-ending machine. (*Courtesy of the John T. Robinson Company.*)

The platen of this machine will collapse unless the operator's hand is removed as the platen closes. The platen is indicated by *A*, and the head of machine, which drives the platen downward, is indicated by *B*.

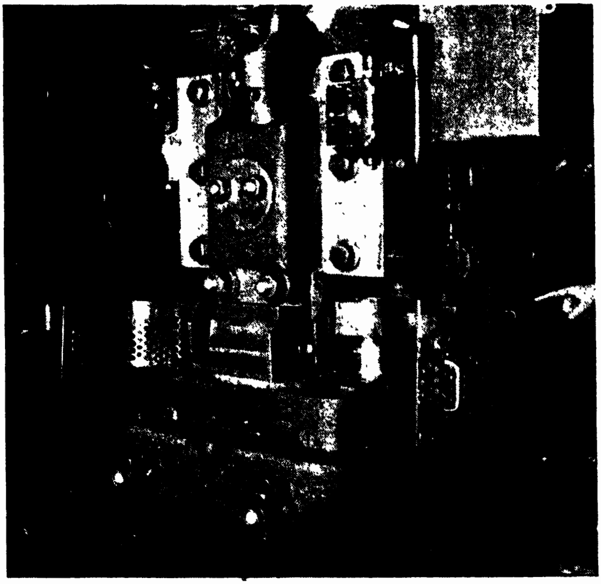


FIG. 60.—Push-button remote control on a punch press. (*Courtesy of the Ford Motor Company.*)

Both buttons must be pressed simultaneously to operate the press. The hand points to a circuit breaker which is wired in series with the push buttons. See Fig. 61. If the inclosure guard is opened the circuit for the electric motor is broken and the press cannot be tripped even though both buttons are pressed.

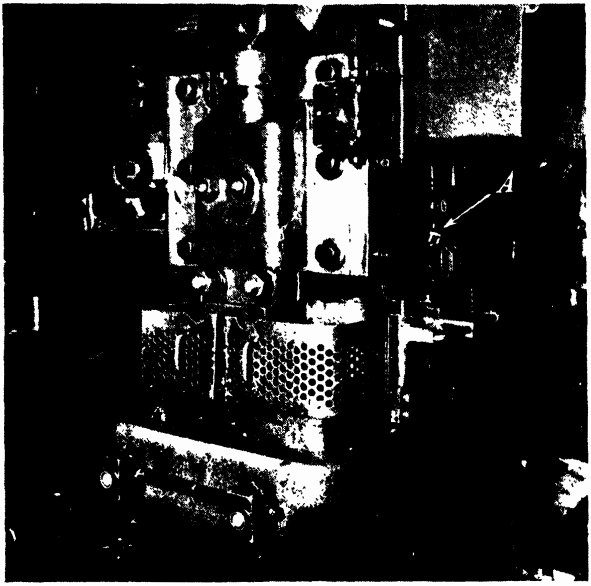


FIG. 61.—Push-button remote control and inclosure guard on a punch press. (*Courtesy of the Ford Motor Company.*)

A combination of two-button control and a substantial inclosure guard is shown. Note the safety plug at *A*, the removal of which prevents accidental starting when changing dies. See Fig. 60.

Group E. Providing Remote-control Operating Mechanisms. One group of point-of-operation safety devices utilizes the remote-control principle, in conjunction with push buttons, switches, levers, or handles. These devices are often designed as tripping or operating controls and in ideal safe practice employ the use of both of the operator's hands. If he removes either hand from the push button or other control device, the motion of the tool is prevented. In other cases the control buttons are located so far away from the machine that the operator cannot reach into the danger zone.

The operator of a dough-mixer that is provided with a safety control mechanism of this kind is obliged to stand out of reach of the machine in order to stop or start it when the tank is in the tilted position with the blades exposed (see Fig. 62). To be sure, only one hand is occupied in operating the controlling device shown, but in this case the operator is well removed from the danger point. In another arrangement of dough-mixer

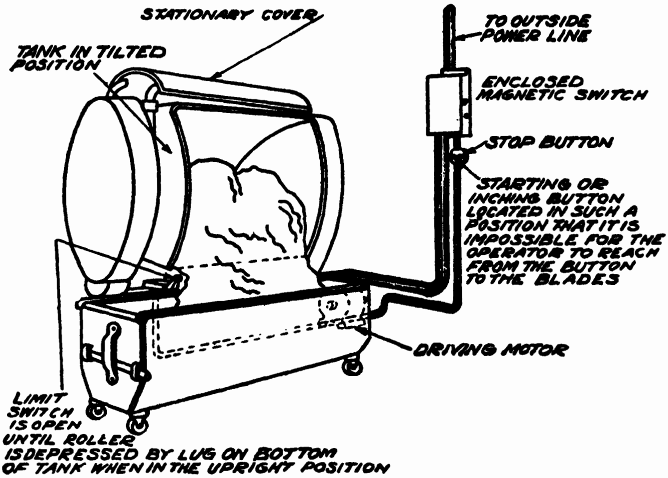


FIG. 62.—Dough mixer with remote control.

A lug attached to the bottom of the tank keeps the limit switch closed as long as the tank is in an upright position at which time it is covered and the blades or paddles are well safeguarded. When the tank is tilted for dumping, the limit switch opens the main operating circuit, and the machine can then be operated only by use of the remote-control buttons. The circuit is so arranged that the operator must keep his finger on the button or the machine will stop.

FIG. 63.—A one-hand tripping device. (*Courtesy of the Worcester Stamped Metal Company.*)

The operator uses one hand to trip the press and the other hand to handle stock with pliers. See the text for comments on the comparative safety of two-hand and one-hand press controls.

control, *two* control buttons are conveniently located on the machine frame, an interlocking cover is provided, automatic feed conveyors are also provided, and the machine is excellently guarded.

Safe hand-control devices may be installed on punch presses. In some cases only one hand is needed to start the press in motion

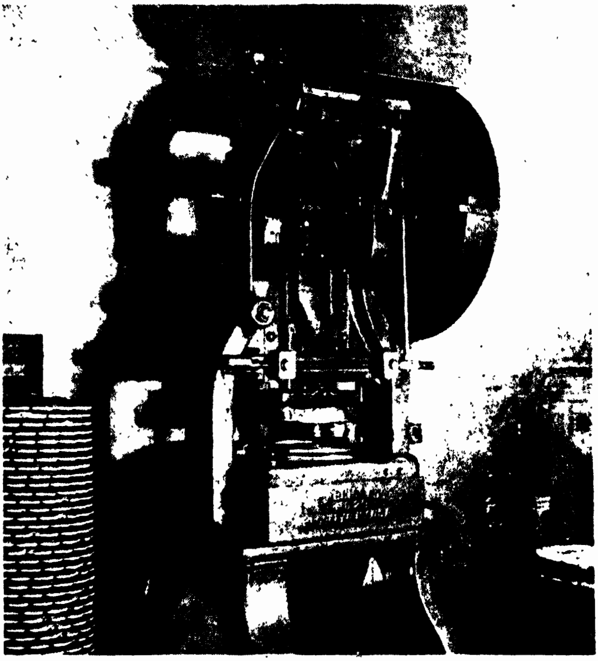


FIG. 64.—Two-button electric control device on a stamping press. (*Courtesy of the Ford Motor Company.*)
Both buttons must be pressed in order that the press may be operated.

while the operation is being performed, but the other hand is used to hold the stock in place and is for the time being in a safe position (see Fig. 63). There is a possibility, with protective devices of this kind, that the operator will insert one hand in the danger zone and trip the machine with the other when no stock is being handled. Devices that require the use of *both* hands are readily available and may be operated by manual force or by electrical, hydraulic, or pneumatic means through the use of buttons, switches, or levers. The attempt here, however, is not to depict guards that will be 100 per cent efficient but to illustrate the several principles of point-of-operation guarding.

Two-handed control devices are applicable to a great variety of machines and operations and, when they are kept in proper operating condition, provide positive protection for the operator (see Figs. 64, 65, 66).

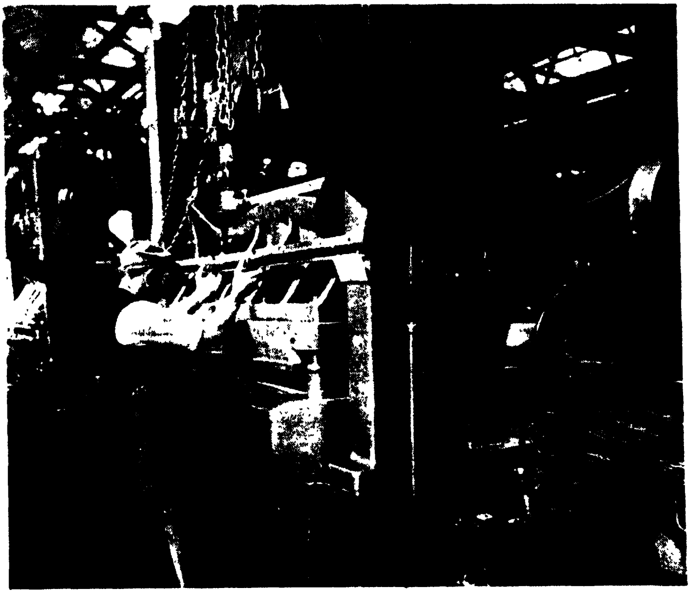


FIG. 65.—A two-button electric control safety device. (*Courtesy of the Ford Motor Company.*)

This device can be employed on a machine that requires two or more men to operate. The wiring circuit in such a case is so arranged that all buttons are in series. This requires each operator or attendant to have his hands on the buttons and not in the danger zone when the press operates.

FIG. 66.—Two-hand control on paper cutter. (*Courtesy of International Business Machines Corporation.*)

Group F. Providing Mechanical Devices That Remove the Hands from the Danger Zone.—A distinctive principle is involved in devices that *remove* the operator's hands from the danger zone. There is no change in design, no inclosure, no interference with the movement of the tool, and no mechanical feed. Mechanical force is employed in such a way that the operator's hands are positively removed from the area of danger whether they are placed there unintentionally or by design. A device is available which is attached to the arms of a punch-press operator and is operated by the movement of the press ram (see Fig. 67).

The so-called "sweep guard" for drop hammers and punch presses is typical of many guards that are arranged to sweep across the tools from side to side or forward and backward, thus pushing away the hands of the operator, in case he should allow them to remain in an unsafe position when the ram of the press descends (see Figs. 68, 69, 70).

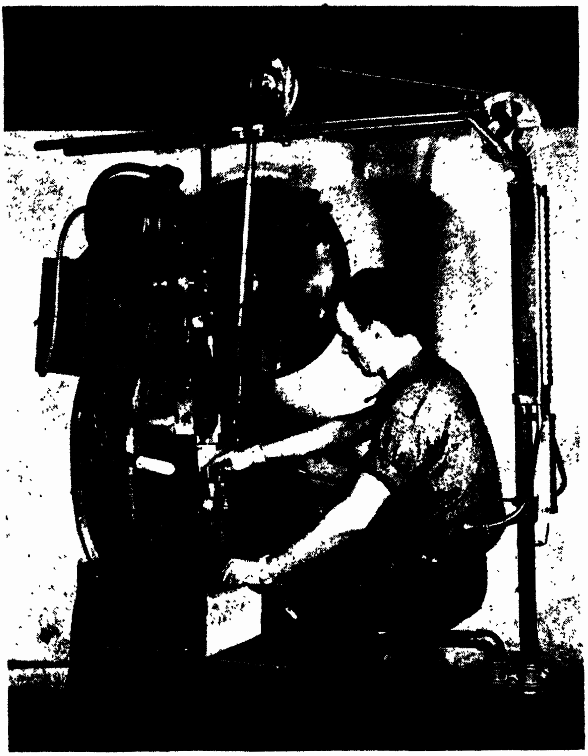


FIG. 67.—Punch press with positively operated hand-strap safety device. (*Courtesy of the Positive Safety Manufacturing Company.*)

Both hands of the operator are pulled away from the danger zone as the ram descends. Cables run from the wrist straps to a vertical standard, through a pipe and across at the top to the ram.

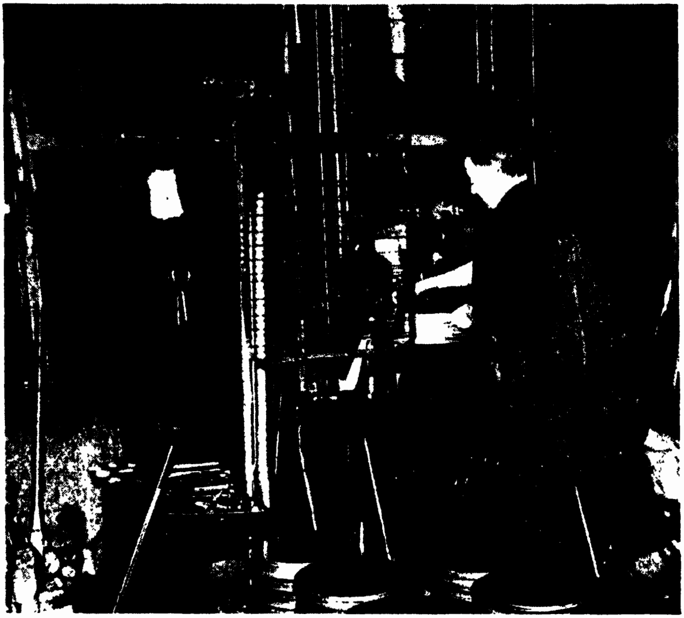


FIG. 68.—A sliding-gate guard on a drawing press. (*Courtesy of the National Conservation Bureau.*)

Gate guard is positive in action, operating from a cam attached to the end of the flywheel shafting. Gate incloses point-of-operation when the upper and lower dies are within 7 inches of each other. Open position is shown.

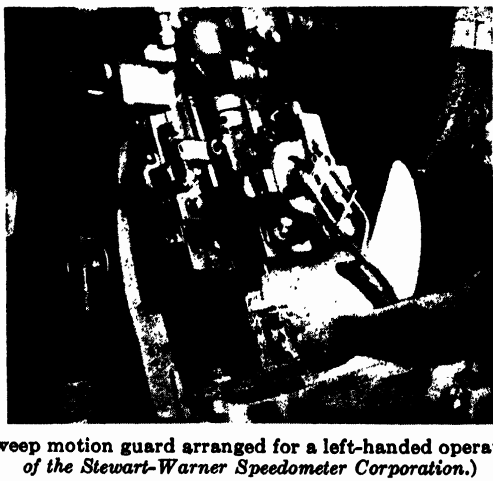


FIG. 69.—A sweep motion guard arranged for a left-handed operator. (*Courtesy of the Stewart-Warner Speedometer Corporation.*)

The guard is operated positively by a simple rack and pinion. The rack is operated by the ram and moves the guard, which is arranged so that it sweeps across in front of the die.

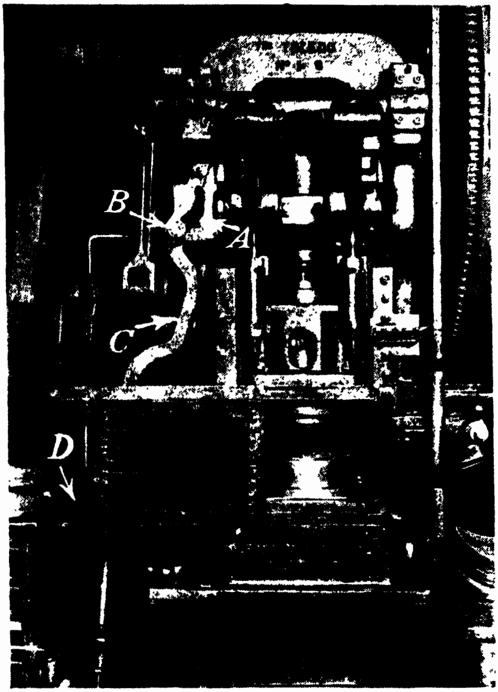


FIG. 70.—A sliding gate-sweep guard on a drawing press. (*Courtesy of the A. J. Lindemann and Hoverson Company.*)

The stud *B* is fastened to the lever *C* and slides in the slot *A*. The lever *C* causes the gate to slide back and forth in front of the die.

Combinations of Devices in Point-of-operation Guarding.—Consideration of some of the several types of devices already referred to suggests that they do not wholly eliminate the hazard at the point-of-operation. The inference, therefore, is correct that more complete protection may be obtained by combining two or more of the devices previously discussed.

For example, a mechanical dial feed for a punch press may be supplemented by a tool inclosure (see Fig. 71). The dial feed makes it *unnecessary* for the operators to expose their hands to danger while feeding stock, and the inclosure *prevents* them from doing so, because it seals off access to the danger zone.

Interlocking devices to prevent the movement of the tool while the operator is exposed to the point-of-operation hazard (Group D) are frequently combined with inclosures (Group B) on extractors (see Fig. 72) and many other machines.

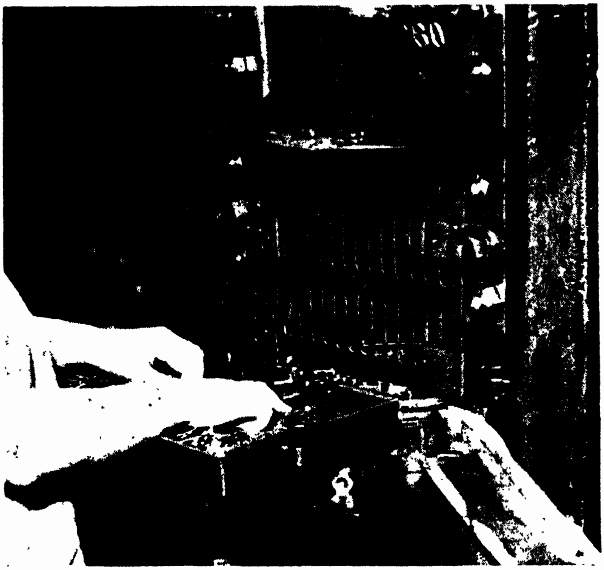


FIG. 71.—Dial feed, plunger inclosure, and automatic ejection for a punch press.

This is an excellent example of combining principles in point-of-operation guarding. A revolving feeding device is shown under the operator's hands. In addition a substantial plunger inclosure blocks the entry of the hands into the danger zone.

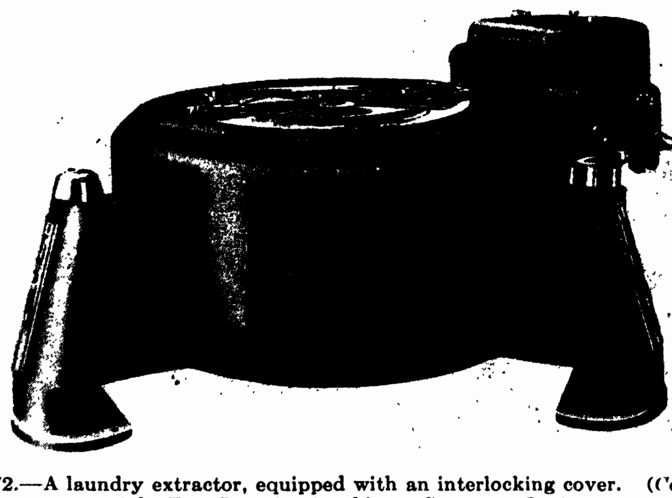


FIG. 72.—A laundry extractor, equipped with an interlocking cover. (*Courtesy of the Troy Laundry Machinery Company, Inc.*)

The machine cannot be started until the cover is closed and locked, nor can the cover be opened until the basket has stopped revolving. This is known as a "full interlock cover" and is an excellent example of combining several of the principles of point-of-operation guarding, including safe tool design, cover protection, and preventing the movement of the tool while the hands are exposed to danger.

There are many other examples of guarding in which two or more principles are included, of which a few typical cases are shown (see Figs. 73, 74, 75, 76).

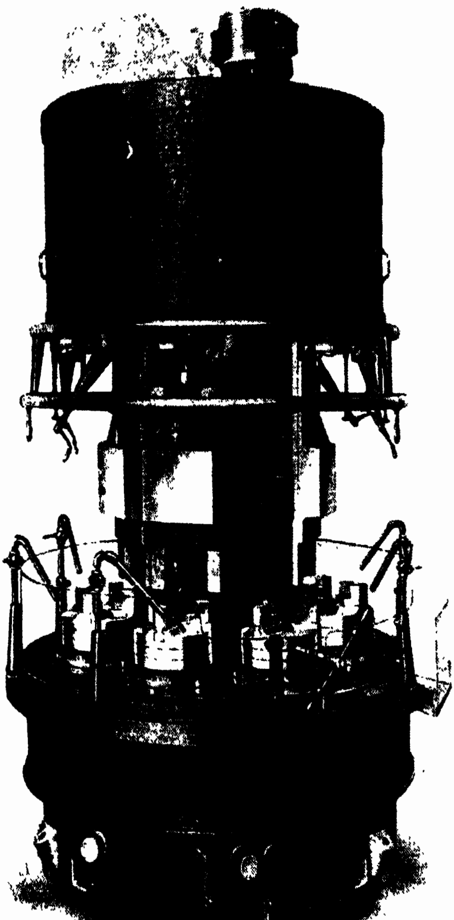


FIG. 73.—A vertical turret lathe. (*Courtesy of The Bullard Company.*)

The multiple points-of-operation are protected by a transparent inclosure guard surrounding the entire working level. Plates and covers over moving machine parts can be easily removed for inspection or adjustment. Individual motor eliminates transmission drives.

FIG. 74.—Carding machine with interlocked complete inclosure. (*Courtesy of the Ford Motor Company.*)

Inside this inclosure is a carding-machine unit. The doors to the inclosure are wired in series. The power will be cut off from the motor if a door is opened. This illustrates a full machine inclosure with electromagnetic motor control. Exhaust ducts carry away the dust, and dust explosion is further guarded against by having the source of illumination outside the inclosure. Note vaporproof globes set outside the inclosure, and wired glass windows.

FIG. 75.—Punch press with gravity-slide feed, plunger inclosure, air-gravity ejection, and hand tools. (*Courtesy of The Milwaukee Stamping Company.*)

Several principles of point-of-operation guarding are combined in protecting this press. Hand tools, plunger barrier or inclosure, and gravity ejection after stripping, are all made use of as safety features.

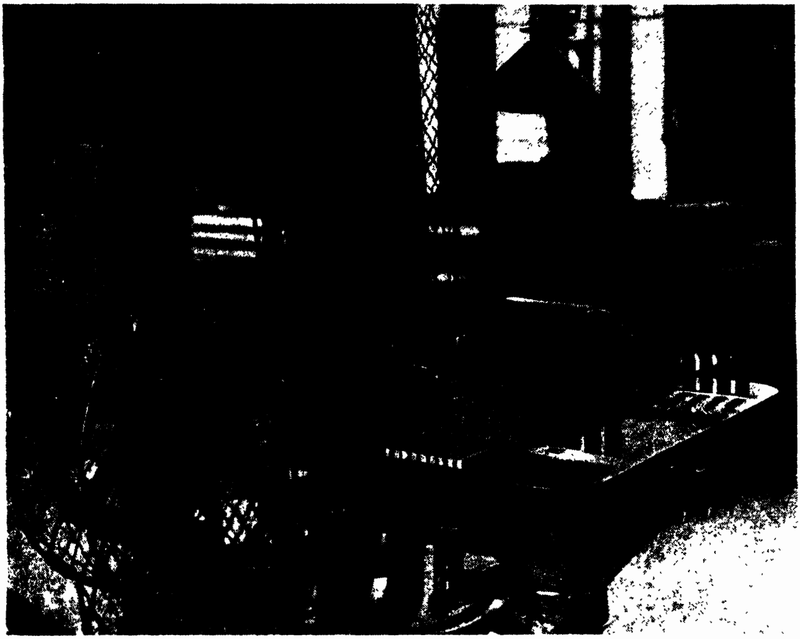


FIG. 76.—Gang saw guarded at the point-of-operation by a combination of devices.

Note the exhaust hood inclosure, roll feed, barrier, and finger guard protection.

Incidental Safety Devices to Reduce the Hazard at the Point-of-operation.—Some devices are designed as accessories that assist in preventing accidents at the point-of-operation of machines. The nonrepeat device on a press is of this class. It prevents unexpected motion of the tools that might be caused if the operator were to "ride" the treadle or trip or fail to remove his foot from the treadle in time to avoid a second stroke of the press (see Fig. 77). Nonrepeat devices are applicable to guillotine paper cutters (see Figs. 78, 79) and to many other machines.

Hand-tool devices designed to make it unnecessary for the operator to expose his hands to danger also may well be included in the list of incidentals (see Fig. 80).

Rubber-mixing mills and other machines that are provided with safety or emergency stops are safer than when not so protected even though the emergency stop in itself is not complete protection (see Figs. 81, 82, 83).

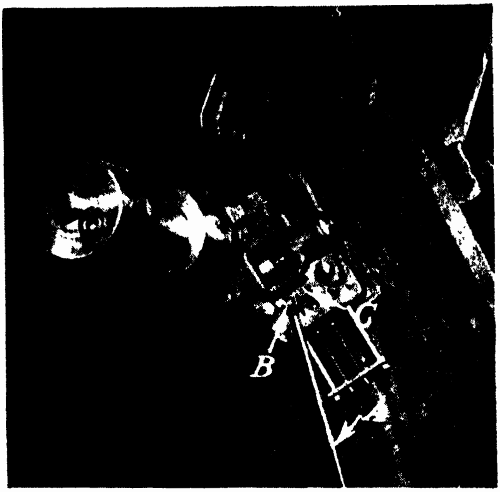


Fig. 77.—Power press with nonrepeat device. (*Courtesy of E. W. Bliss Company.*)

When the treadle rod *A* is connected to the stud *B*, the press will continue to operate as long as the treadle is depressed. The nonrepeat device is brought into action by disconnecting the rod *A* from the stud *B* and connecting it to stud *C*.

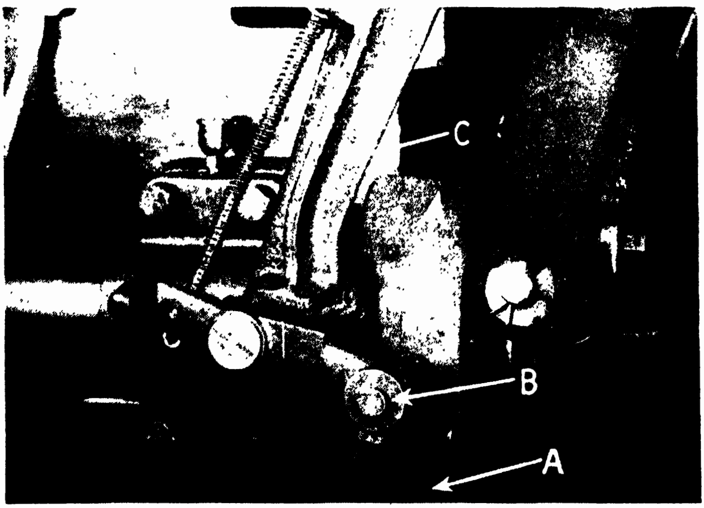


Fig. 78.—Clutch throwout mechanism (nonrepeat device) on a guillotine paper cutter. (*Courtesy of Seybold Machine Company Division of the Harris-Seybold-Potter Company.*)

Cam *A* revolves as shown by the arrow and engages with the roller on arm *B*, thus forcing *B* and the lever *C* to a position which throws out the clutch, applies the brake, and stops the machine. This permits but one stroke of the machine at one time. See Fig. 79 for another illustration of the same device.

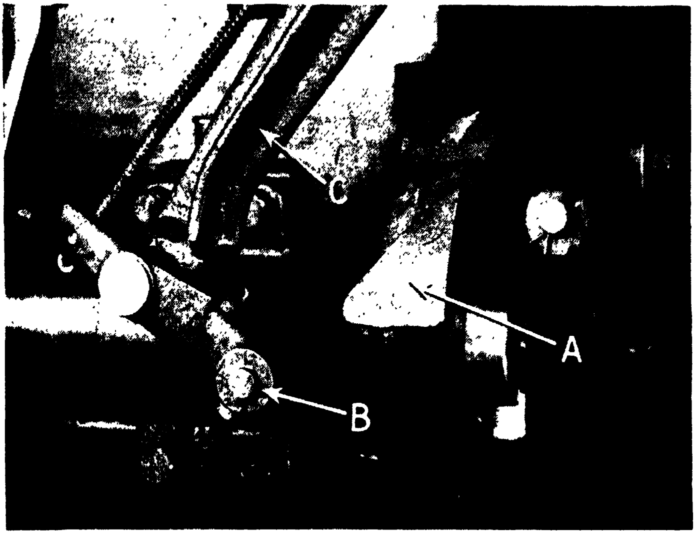


FIG. 79.—Guillotine paper cutter, showing nonrepeat device in the tripped-out position. (*Courtesy of Seybold Machine Company Division of the Harris-Seybold-Potter Company.*)

The lever *B* and the arm *C* have been forced to the left by the cam *A*. The machine can now be started again by the operator. See Fig. 78, which shows the mechanism just before the cam engages the roller *B* on the lever.

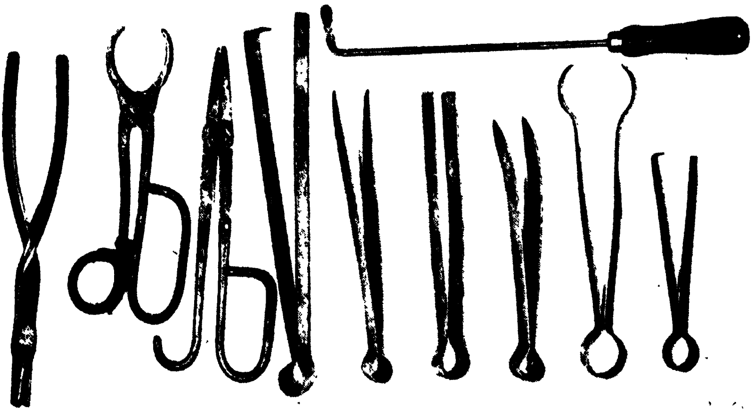


FIG. 80.—An assortment of hand tools for press work. (*Courtesy of the Ford Motor Company.*)

Each tool is especially designed for a particular operation and form of product and is of such shape and length that, when used as intended, the operator's hands do not enter the danger zone.

Fig. 81.—Rubber mill with an emergency stop device. (*Courtesy of The Carborundum Company.*)

If the bar is depressed by the operator in an emergency, the rolls will be stopped and a serious injury will be prevented.

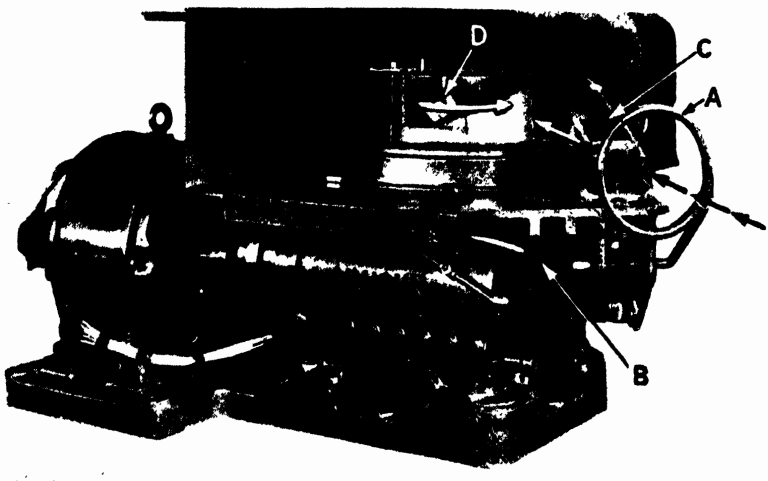


Fig. 82.—Wire-drawing machine with automatic safety trip. (*Courtesy of the Vaughn Machinery Company.*)

The safety ring *A*, through which the wire is drawn to the machine, is connected to tripping mechanism *B*. If the hands are pulled against the ring the machine is tripped out and stops. Note arrows showing the direction of rotation of spool *D*.

Automatic feeding devices are often manufactured independently of the production machine to which they may later be attached. When so designed and manufactured they may be used in conjunction with many machine operations and in facilitating the sorting and handling of a wide variety of small parts (see Fig. 84).

FIG. 83.—Calendar stack with safety trip. (*Courtesy of Wm. R. Thropp & Sons Company.*)

If the operator's arm should become caught while starting the calendar and feeding friction on take-up, he can stop the calendar by pulling on the safety cable.

Among the many other incidental safety devices should be included the treadle guard, the pusher block (see Fig. 85) the safety net (see Fig. 86) and catch scaffold, reflector (see Fig. 87) at blind corners, locks, warning gongs, telltale chains and alarms, temperature and pressure controls, and mechanical belt shifters (see Fig. 88).

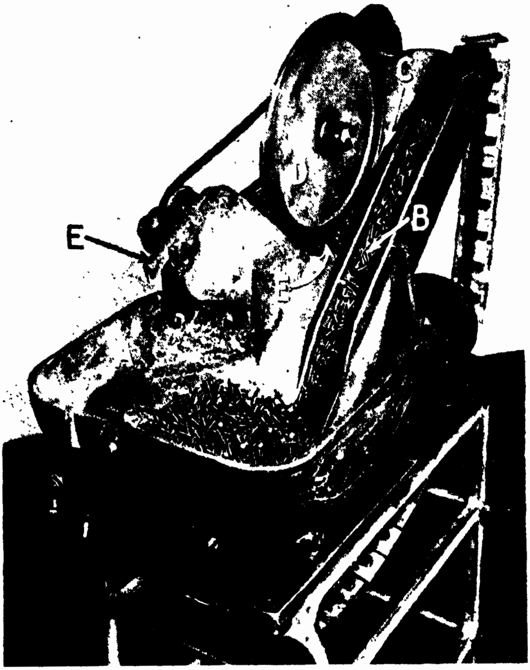


FIG. 84.—Automatic feeding machine. (*Courtesy of The Asa S. Cook Company.*)

This machine is designed as a separate complete unit for feeding small parts. It handles over 100 pieces per minute. As shown, it is handling small wood screws. The screws in the bowl of the hopper at *A* are elevated by conveyor *B* to chute *C*. They are aligned by disk *D* and pushed into chute *E* which conveys them to the machine (not shown) where they are used. This machine eliminates the hazards of handling small parts at the point-of-operation of other machines to which it is attached.

Fig. 85.—Pusher block for a jointer.

This illustration shows jointer (cylinder head not shown) apron guard and pusher block. The end of the block that is toward the operator has an offset or shoulder which fits over the stock.

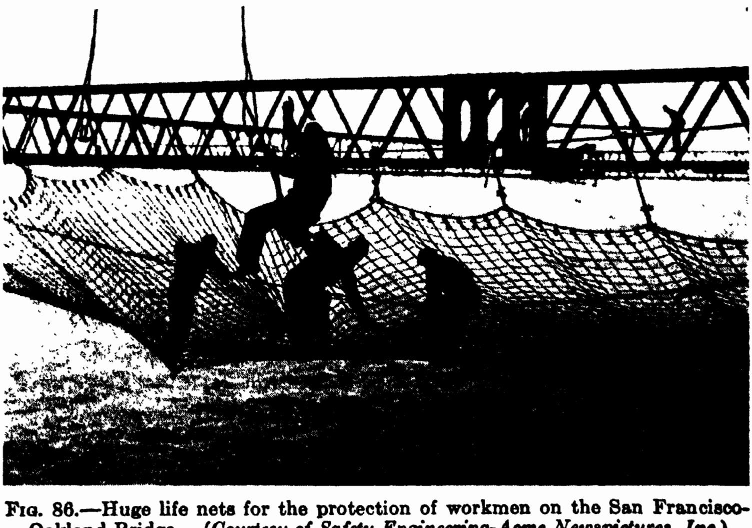


Fig. 86.—Huge life nets for the protection of workmen on the San Francisco-Oakland Bridge. (*Courtesy of Safety Engineering-Acme Newspictures, Inc.*)

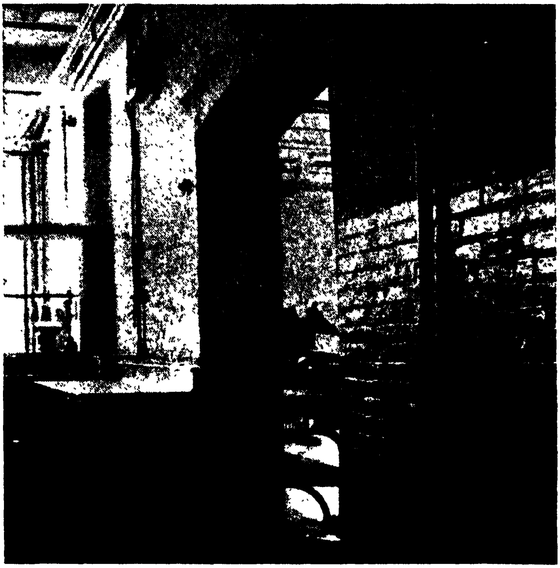


FIG. 87.—Blind corner mirror. (*Courtesy of the National Conservation Bureau.*)

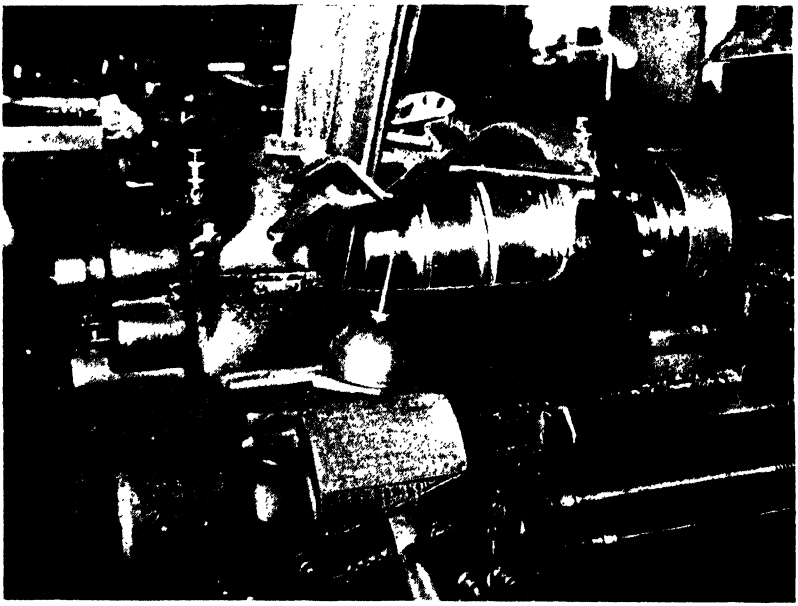


FIG. 88.—Cone-pulley belt shifter. (*Courtesy, National Conservation Bureau.*) The figure shows the lower half of a homemade cone-pulley belt shifter.

Application of Principles in Point-of-operation Guarding.—In the preceding section relating to point-of-operation safeguarding, the *principles* that underlie successful accident-prevention work in this particular field have been stated. The few illustrations used are merely typical of thousands of guards and safety devices designed in accordance with the various principles or with combinations of them. It is impossible to prepare an exposition so complete that the interested safety engineer could hope to find therein exactly the type of guard he required for any operation on any machine. In these fundamentals, however, he can find the method of solving successfully any problem that might be presented to him.

One example may sufficiently illustrate the point, and selection is made again from the fertile field of metalworking. In connection with a certain punch-press operation, the operator was required to use both hands to hold two pieces of stock in place while the pieces were being riveted together. Many injuries occurred, and, although the management was extremely desirous of preventing them, nothing had been accomplished in this direction for over a year, because of certain apparently insurmountable difficulties. The principles here explained were then applied, and in three hours the situation was permanently remedied at little or no cost in time or money. One principle after another was considered thoroughly. It was thought too expensive to make another complete set of new tools of better design, meanwhile making use of the existing set. Inclosures could not be used because it was necessary for the operator's hands to remain in the danger zone in order to hold the work in position. Automatic mechanical feed was impracticable. It was impossible, moreover, to use two-handed trips or other devices requiring the removal of the hands from the area of hazard; and it was equally impracticable to employ devices designed to interrupt or prevent the movement of the dies until the space between them was clear. Hand tools were considered, but the job required that the sense of touch be used. It was decided finally that tool design would undoubtedly solve the problem. The tools themselves could be so redesigned as to hold the work rigidly in position, thereby permitting the use of a gate guard or a two-handed trip. The job could not be stopped long enough to make tool changes, and so consideration was given to the use of a short-stroke press similar to that shown in Fig. 16. A press of this kind, having not over $\frac{3}{8}$-inch plunger travel was available. The tools were transferred to this press where it was found that there was sufficient room for the handling of the stock but not enough clearance for the fingers to come under the riveting tools. The transferred job was thereafter conducted safely.

As described, the reader's reaction may be that this ultimate procedure was so simple that it should have been adopted in the first place. Of course it is a simple solution, but bear this in mind—so too would be many other remedies if the application of principles had shown them to be practicable. The problem of guarding is simplified by using planned procedure instead of less effective methods. In these principles there is the basis for point-of-operation guarding of all kinds. Familiarity with them provides a comprehensive picture of guarding possibilities. The engineer is enabled to direct his thoughts and ingenuity, step by step, over the entire field. If he can think of no appropriate device or adaptation of a device in any one group, he proceeds to another group until all are exhausted; and if then he has found no solution it is probably because expense stands in the way or because ability is lacking. That this last statement is true is indicated by the generally admitted fact that in this age of mechanical genius tools and machines (disregarding first cost) can be designed to perform practically any industrial mechanical operation automatically without requiring the exposure of the operator's hands to danger.

MACHINE GUARDING OTHER THAN POINT-OF-OPERATION

This section relates to the belts, pulleys, gears, shafts and shaft ends, screws, projections, and all other moving machine parts, other than point-of-operation, that constitute potential injury-producing conditions. Again it is possible to benefit by the knowledge of fundamentals or principles. These are given in the following list:

1. Dangerous moving parts should be inclosed.
2. Parts subject to wear, adjustment, and hand lubrication should be conveniently accessible.

3. Lubrication should wherever possible be automatic and continuous when the machine is in operation.

4. Consideration should be given to individual drive so that hazards due to driving mechanism may be minimized.

5. Sharp contrast between light and shadow and glare in the vicinity of the point-of-operation should be avoided. Consideration in designing machines should be given to the provision of integrally mounted lights or to the probable position of independent lighting units.

6. Materials should be mechanically conveyed to, and product from, machines wherever possible.

7. Provision should be made for automatically conveying dusts and gases away from machine.

8. Noise should be eliminated or reduced to the maximum extent.

9. Vibration should be eliminated or reduced to the maximum extent.

10. Machine motions tiring to the eyes should be avoided, as when reciprocating or revolving parts must be viewed through cross screens or latticework.

11. Exterior shapes of any parts of the machines that require frequent contacting or handling should be such as to facilitate convenience in handling, and moving parts that cannot be inclosed should, as far as possible, be smooth in contour.

12. Weight of parts to be handled should be kept within the limits of convenience, or these parts should be so designed that they may be conveniently handled by mechanical means.

13. Throughout the design of the machine and its parts, consideration should be given to convenience in attaching accessories, chiefly point-of-operation guards or guards for moving parts. The thought here is that bosses may be cast on the framework of machines in such manner as to permit drilling, tapping, and the bolting on of accessories without weakening the structure of the machine itself.

14. Consideration in design should be given to the external shape of the machine unit so that the danger of accident from tripping and falling and collision will be minimized. Splay-footed supports, for example, that stand out from the body of the machine sometimes cause a tripping hazard. Corners may often be rounded to lessen the danger from accidental contact.

15. Liberal factors of safety should be used in determining the strength of parts.

16. Wherever manufacturing circumstances permit, point-of-operation guards should be installed by the builder of the machine so that it may be delivered to the purchaser in a fully guarded condition.

17. Consideration should be given to the safe location or isolation of machines that cannot be made safe otherwise.

Design for Safety.—The best opportunity to prevent accidents on machines, as has already been pointed out in the preceding section on point-of-operation guarding, lies with the machine manufacturer and his staff of designers and draftsmen. If accident prevention receives the consideration that it so well deserves in the creative stages of machine manufacture, the finished product will need relatively little alteration to be reasonably safe.

Just as careful thought should be given to the design of *machines* for safe operation as to the design or subsequent safe-

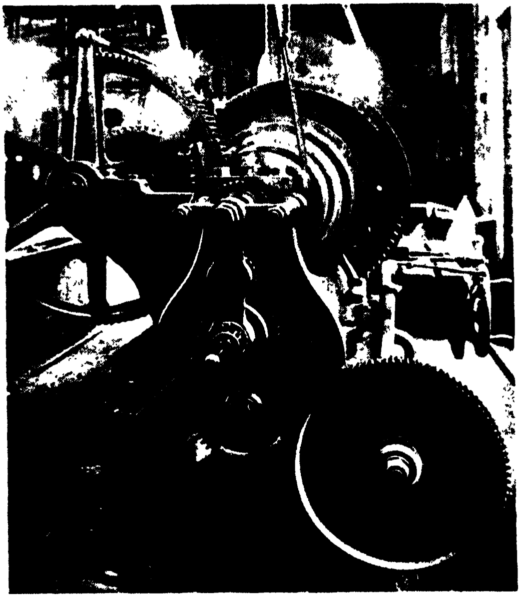


Fig. 89.—An old-style engine lathe.
Note exposed change, back, and feed gears. See Fig. 90 for contrast with newer design.

guarding of the *point-of operation* of tools that are used in connection with these machines.

The application of some of these principles of safe machine design and installation is well exemplified by many thousands of machines of various types, formerly designed without much thought of safety and now produced with dangerous moving parts and other hazards well protected. A few examples follow that vividly portray the progress that has been made (see Figs. 89, 90, 91, 92, 93, 94, 95, 96, 97).

The newer machines of improved design may have as many moving parts that have the potential power to crush, shear, and

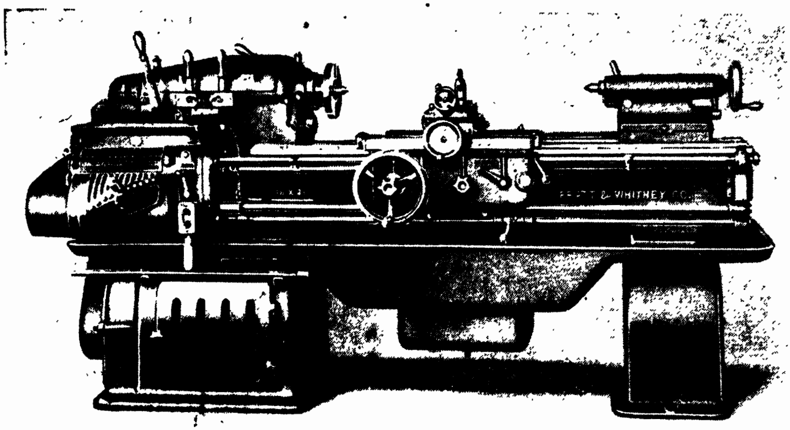


FIG. 90.—A good example of safe engine-lathe design. (*Courtesy of the Pratt & Whitney Company.*)

This machine is individually driven; all gears are inclosed in the head. Levers that control the various speeds and feeds are conveniently located to facilitate operation. Contrast this design with Fig. 89.

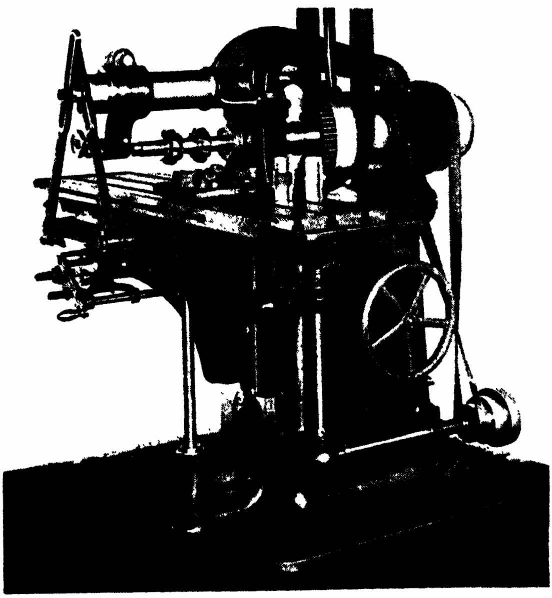


FIG. 91.—Belt-driven universal milling machine. (*Courtesy of The Brown & Sharpe Manufacturing Company.*)

Many similar machines are still in use. The change from belted machines with exposed gears, belts, and shafting has been marked. See contrast with Fig. 92.

mangle the human body as earlier models, but the dangerous parts of modern mechanical devices are hidden or covered by substantial guards that are incorporated as integral parts of the machines.

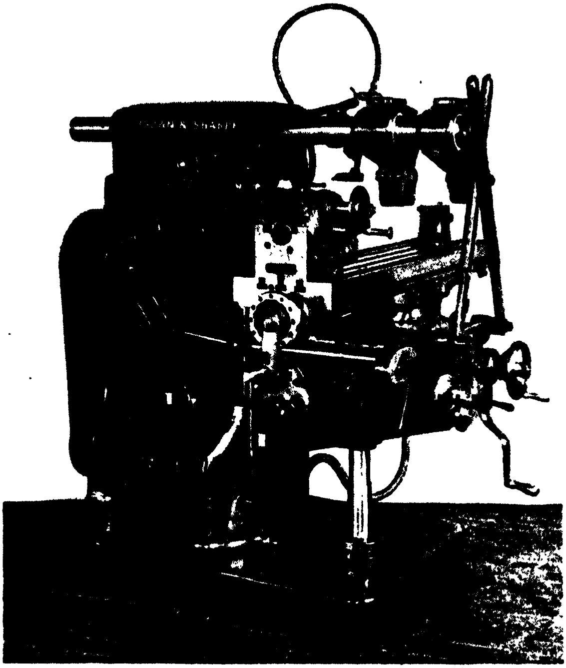


FIG. 92.—Universal milling machine with individual drive and guarded parts. (*Courtesy of The Brown & Sharpe Manufacturing Company.*) Note improvement in design over the machine in Fig. 91.

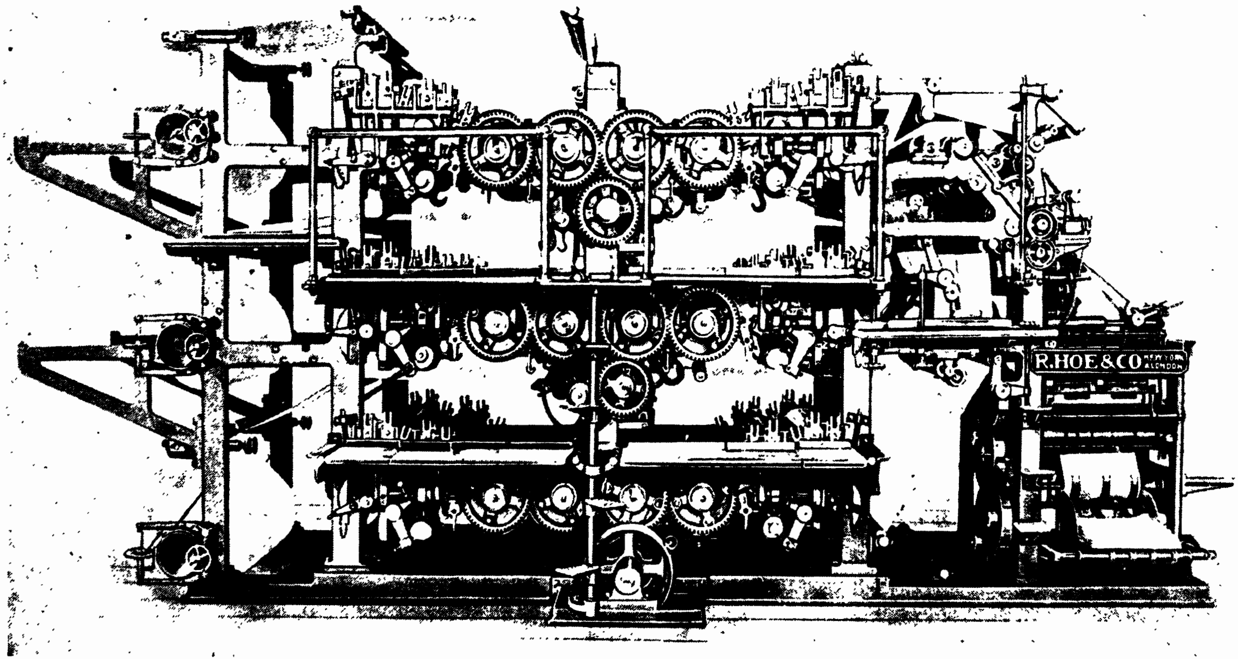


FIG. 93.—News printing press with unguarded parts. (*Courtesy of R. Hoe and Company, Inc.*)

News printing presses have a mass of moving parts. Pressmen must work in close proximity to gears, shafting, cams, and other dangerous moving parts. Figures 94 and 95 show what improvement in design has accomplished.

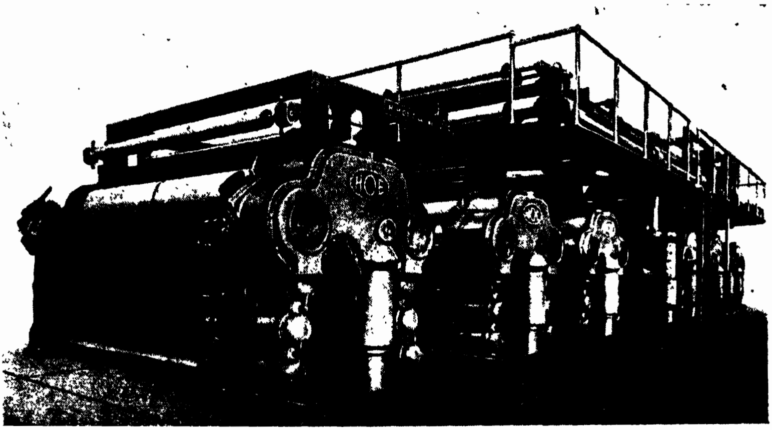


FIG. 94.—An improved multiple-unit printing press. (*Courtesy of R. Hoe and Company, Inc.*)

Note the lack of dangerous moving parts in contrast to the press shown in Fig. 93. This has been accomplished by simplification in design and by clever guarding. Particularly striking is the provision for inspecting the gears through glass plates. See Fig. 95.

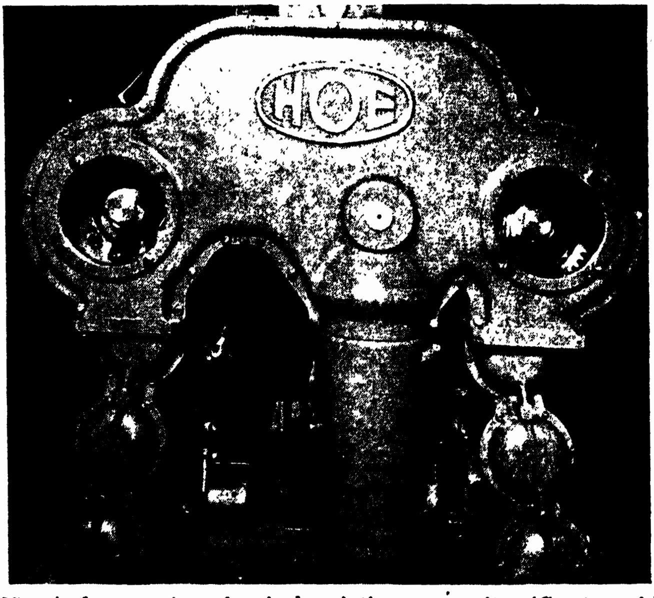


FIG. 95.—A close-up view of a single printing-press unit. (*Courtesy of R. Hoe and Company, Inc.*)

The machine shown in Fig. 94 contains several such units. Note the guarding of dangerous moving parts in contrast to the exposures on the machine illustrated in Fig. 93. As shown in Fig. 94, glass plates are provided for the inspection of the gears at the upper left and right openings.

FIG. 96.—Radial drill with unguarded machine hazards. (*Courtesy of The Cincinnati Bickford Tool Company.*)

Belts, pulleys, gears, and shafting have largely been eliminated on radial drills. See Fig. 97 for contrast with a similar machine having guarded parts.

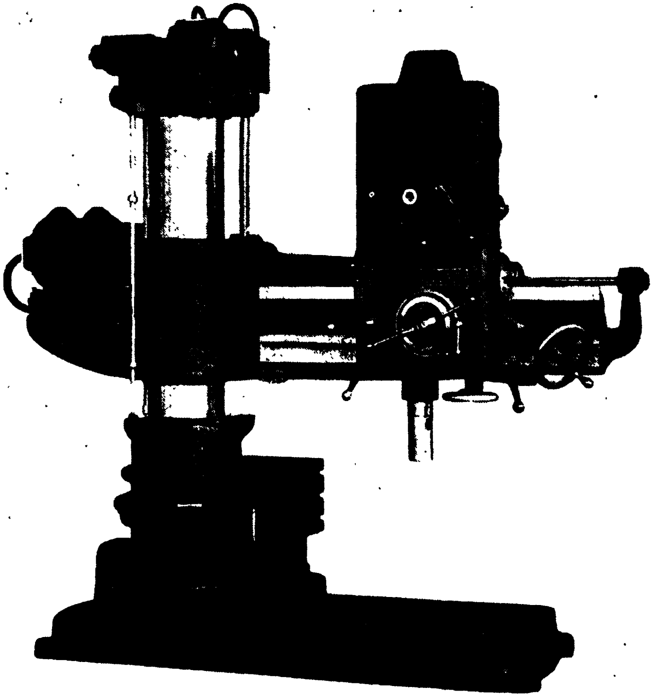


FIG. 97.—Individually driven, well-guarded, radial drill. (*Courtesy of The Cincinnati Bickford Tool Company.*)

This machine is equipped with inbuilt guards wherever possible. The various control levers facilitate operation and make it safer. Note improvement over the machine in Fig. 96.

Individual Motor Drive.—In other cases new design has simplified the mechanism and eliminated danger points that formerly required guarding. The application of "individual motor drive" is a notable example. Figure 98 shows a vertical drill press with an individual motor drive that has displaced the belts, cone pulleys, and overhead gears that were necessary on the old type of drill press shown in Fig. 99.

Other machines, in practically all lines of industry, that were at one time delivered to the purchaser with gears, pulleys, and other moving parts exposed, have now been greatly improved and simplified chiefly because of the use of individual drive (see Figs. 100, 101, 102).

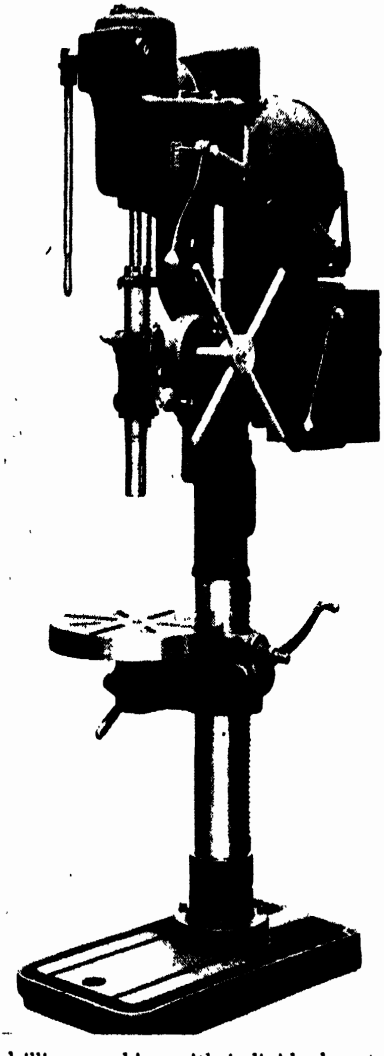


FIG. 98.—Vertical drilling machine with individual motor drive. (*Courtesy of The Cincinnati Bickford Tool Company.*)

This drilling machine presents a clean-cut appearance. The only mechanically driven exposure is the spindle. See Fig. 99 for an illustration of the same kind of machine but with belt and pulley and partial gear exposure.

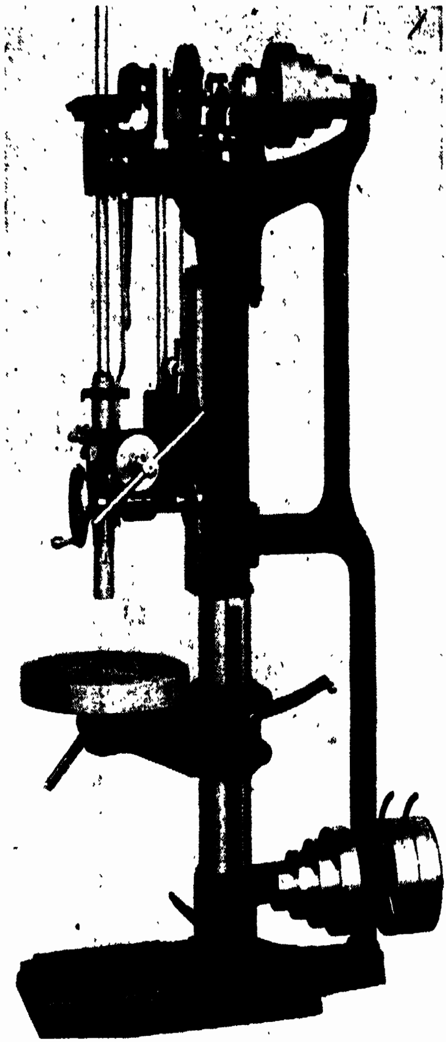


FIG. 99.—Partially guarded vertical drilling machine. (*Courtesy of The Cincinnati Bickford Tool Company.*)

For the period in which this drilling machine was built, the inbuilt gear guards and feeding device were quite satisfactory. The belts and pulleys constituted the chief hazard. As a matter of contrast, however, see Fig. 98, which shows marked improvement in design.

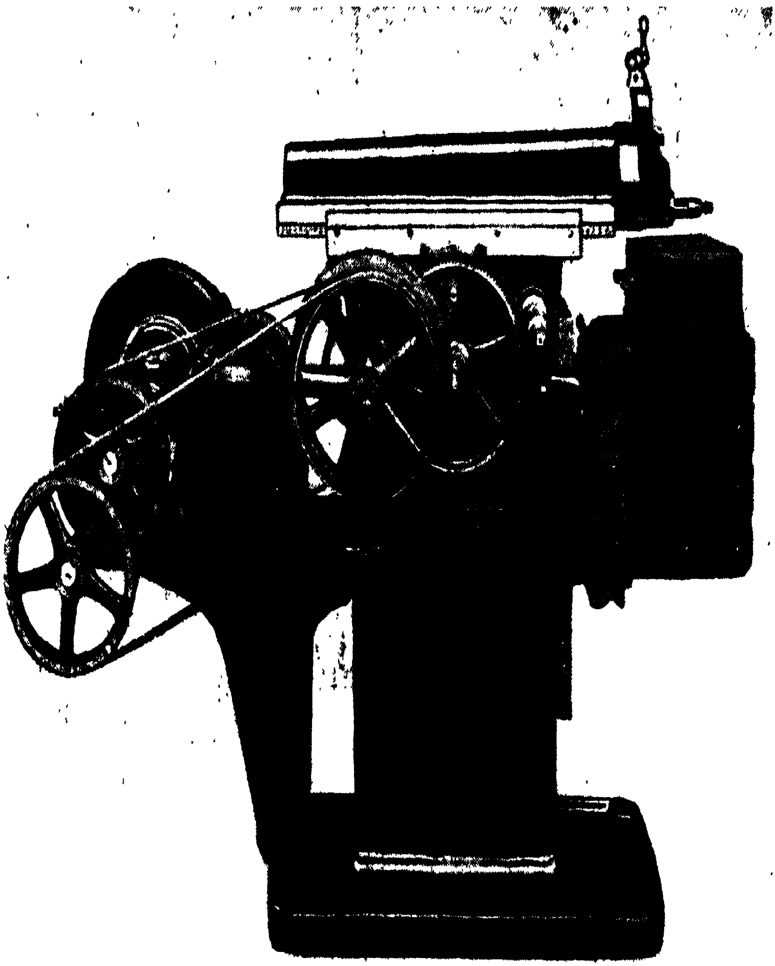


FIG. 100.—Metal-shaper belt driven from individual motor. (*Courtesy of The Hendey Machine Company.*)

This design illustrates an intermediate step between the machine driven from line shafting, and the simplified direct-driven inclined-type machine shown in Fig. 101.

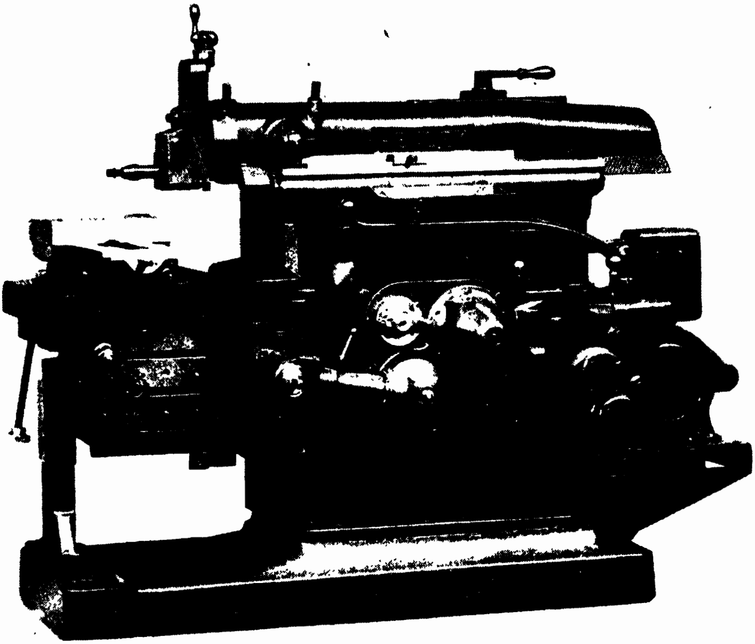


Fig. 101.—Individually driven metal shaper. (*Courtesy, Hendey Machine Co.*)

The design is sturdy and compact. The crank drive for the ram is inside the frame, and the gears and other moving parts are well inclosed. Note the absence of the belts and pulleys that are in evidence on the older type machine shown in Fig. 100.

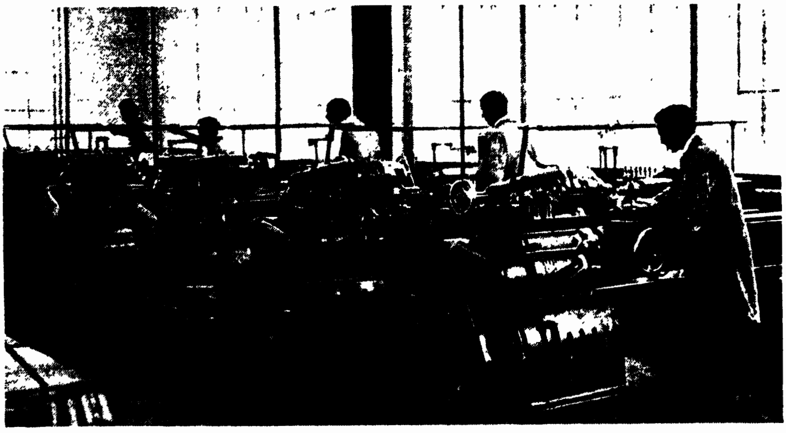


Fig. 102.—A group of individually driven engine lathes. (*Courtesy of The Pratt and Whitney Aircraft Company.*)

Note that the machines are so arranged at right angles to the windows as to take advantage of natural light. The entire absence of transmission shafting, belts, and pulleys, and of attendant hazards is strikingly portrayed.

Elimination of Hand Power.—Progress in machine design has eliminated many manual operations with their attendant hazards. The evolution of the power shovel is one good example of this development. Power shovels with single-load bucket capacities of over 13 tons, and having a vertical sweep of more than 60 feet, are being made (see Fig. 103).

It is undoubtedly true that the introduction of machinery to replace hand labor, though removing or minimizing one kind of hazard, at the same time introduces other mechanical hazards that did not formerly exist. It is only necessary, however, to consider the vastly greater number of men, all exposed to the previous dangers of hand operations, that would be required to produce the quantity of commercial products now consumed if improvement in methods of production had not occurred, to visualize the great reduction of hazards that the invention of machinery has brought about.

The trench digger is another type of machine that reduces accident frequency by eliminating dangerous hand labor (see Fig. 104).

In the metalworking field the bulldozer is so designed as to perform automatically a great variety of hot swaging, forging, forming, and bending operations formerly requiring semihazardous hand labor (see Fig. 105).

Developments in the art of commercial glassmaking have produced the automatic glass machine which also tends, through elimination of hand labor, to reduce the probability of accidents (see Figs. 106, 107).

An almost endless list of illustrations taken from practically every branch of industry could be given, showing how, through improvement in machine design and the substitution of newly devised machines for dangerous hand methods, it has been possible to increase production without sacrificing quality and to do the work at less cost and with fewer accidents.

To the safety engineer in the shop, however, who is obliged to deal with machines "as they are," there is little immediate consolation in the thought that further progress will eventually iron out his problems. He is confronted with the fact that certain of the machines that employees now operate have caused injuries in the past and may continue to do so in the

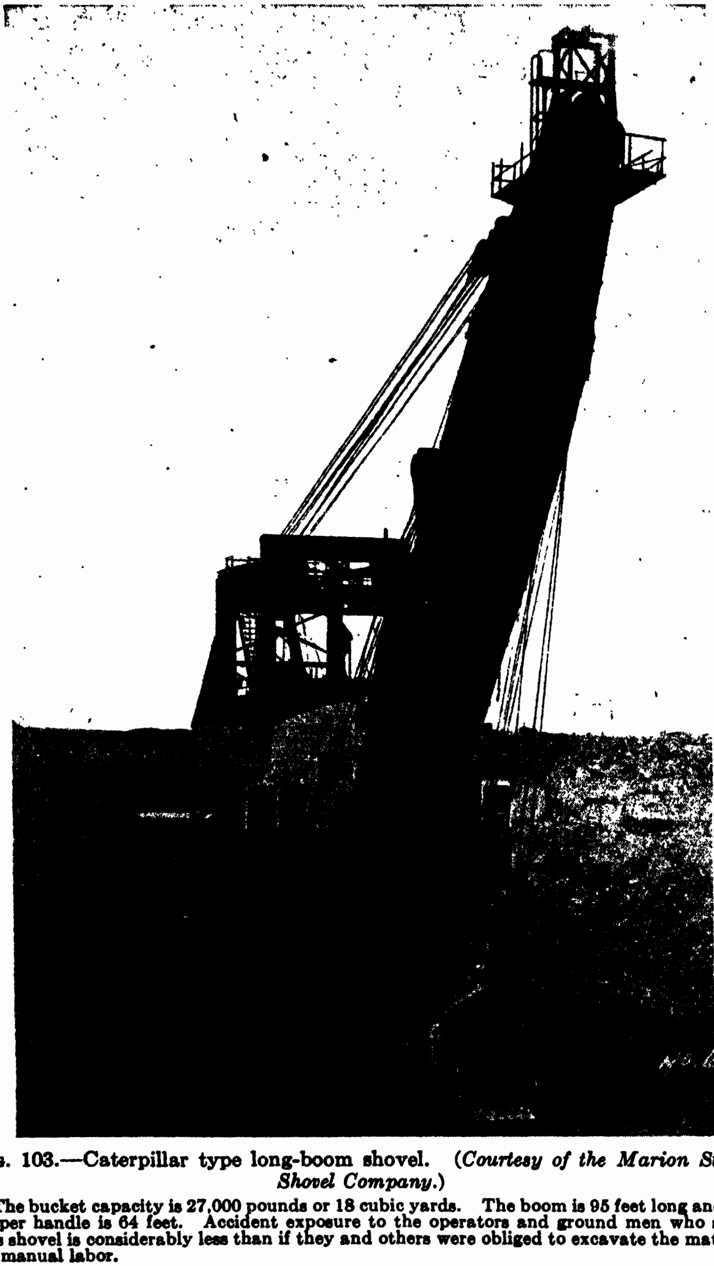


FIG. 103.—Caterpillar type long-boom shovel. (*Courtesy of the Marion Steam Shovel Company.*)

The bucket capacity is 27,000 pounds or 18 cubic yards. The boom is 95 feet long and the dipper handle is 64 feet. Accident exposure to the operators and ground men who serve this shovel is considerably less than if they and others were obliged to excavate the material by manual labor.

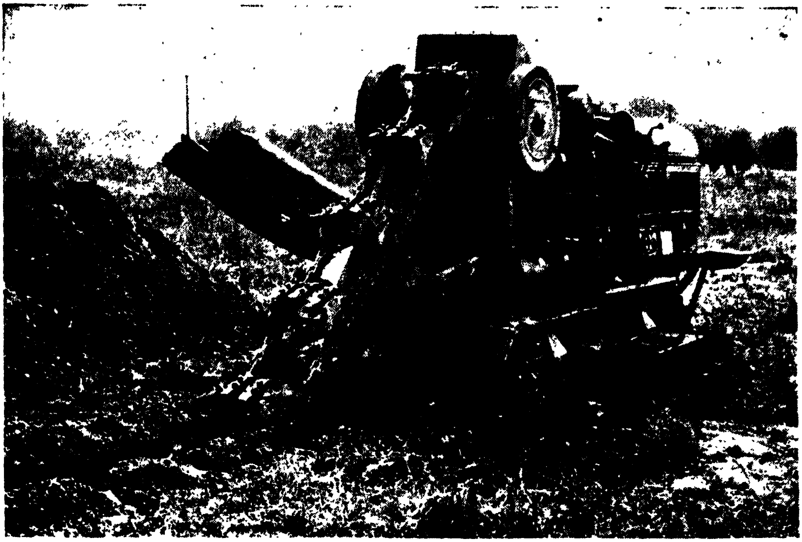


FIG. 104.—A small trench excavator. (*Courtesy of The Buckeye Traction Ditcher Company.*)

Note the convenient location of all controls and the cover guards for the drive mechanism.

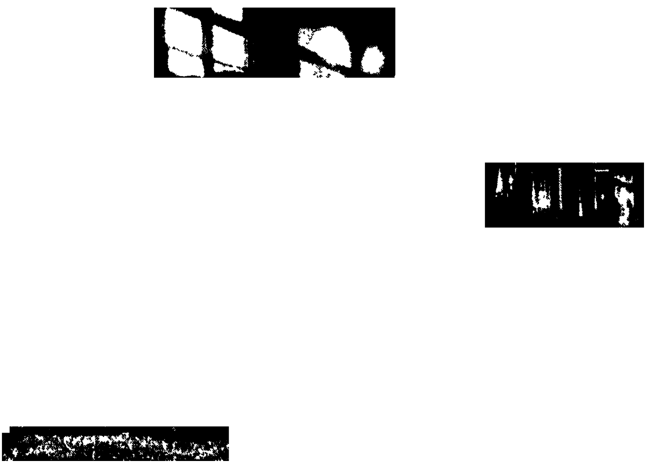


FIG. 105.—A bulldozer for shaping heavy metal pieces. (*Courtesy of Williams, White and Company.*)

This machine exerts great pressure at the point-of-operation because of its reduction-gear drive. It produces a variety of heavy hot-forged or swaged parts.

future. He is interested not so much in the design of new machines, but in guarding existing dangerous machines. The following section of this chapter relates to the guarding of existing exposures.

FIG. 106.—Blowing hollow glassware by the old method.

For some kinds of work this method is still employed. Contrast this practice and its attendant hazards with the automatic glass-bottle making machine in Fig. 107.

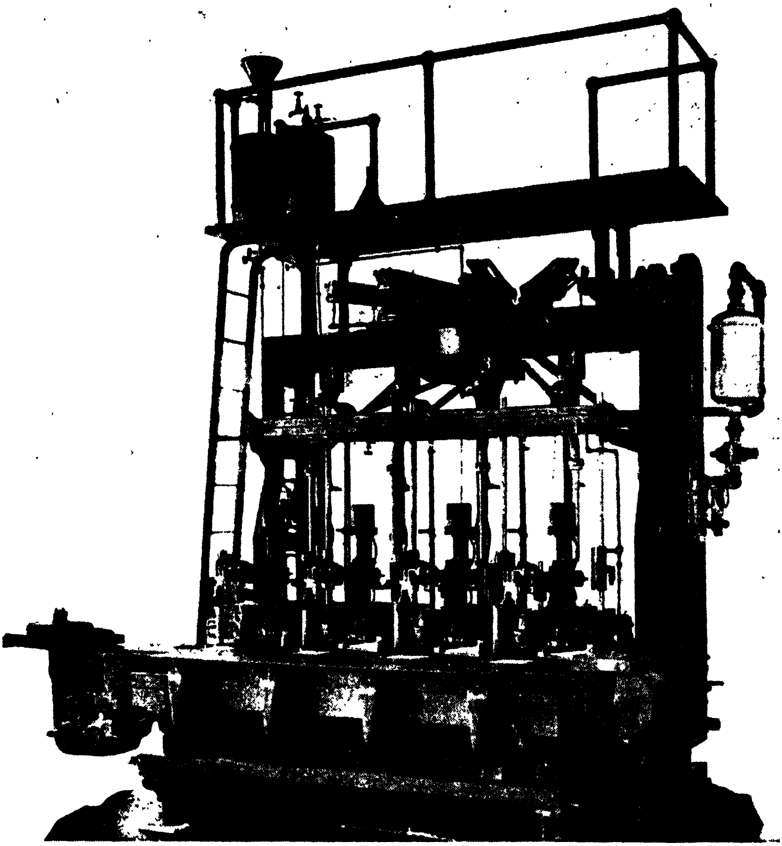


FIG. 107.—A glass-bottle-forming machine. (*Courtesy of the Hartford Empire Company.*)

This machine is widely used for the manufacture of glass bottles and jars of from fractional ounce weight to one gallon capacity. This straight-line machine has no large moving parts, rotating tables, or arms and is conducive to safe operation. Screen guards inclose shafting and connected parts.

Inclosures, Covers, and Barricades for Machines.—The problems arising in the guarding of existing machines, at points other than the point-of-operation on these machines, are relatively simple matters. Except as described under "Safe Location and Arrangement of Machines,"[1] it is only necessary to consider the several forms of inclosures, covers, or barricades that may be used to prevent accidental contact with moving parts, and

[1] See p. 245.

certain incidental safety factors of lesser importance. It is safer to guard each individual part of a machine than to leave such parts unguarded and to rely for protection upon a rail or inclosure placed about the entire machine. Paper machines and printing presses, for example, with their many gears, shaft ends, belts, and pulleys, may be guarded by rails, but they would be much safer and the machines would be more easily accessible if the individual danger points were separately inclosed.

The complete individual inclosure is one of the more satisfactory of the different kinds of machine guards. This is particularly true in connection with gears that, because of their broken and sharp-corner contours and indrawing power at the meshing point, are considerably more dangerous than belts and pulleys of similar size operating at the same speed. Several excellent methods of guarding gears by complete cast-iron or steel housings attached to the frames of the machines (see Figs. 94, 95, 97, 98, 101, 102) have been shown in the preceding figures. Other examples of solid and wire-mesh gear guards are also shown (see Figs. 108, 109).

Belts and pulleys and other moving parts may be satisfactorily guarded by solid, perforated, or expanded metal and by wire-mesh or wooden inclosures (see Fig. 110).

Projecting parts (both revolving and reciprocating) may be covered or inclosed in a similar manner. Many machines present a wide variety of moving-part hazards grouped in a relatively small area. The card is an example, and the inclosure type of guard is well adapted to this machine (see Figs. 111, 112).

Shafts and shaft ends may cause injuries and should receive consideration in machine guarding. The inclosure is well adpated for this work.

Blanking (covering the spaces between the spokes) of pulleys and flywheels is often resorted to in order that the danger of contact with moving spokes may be minimized. This is also a form of inclosure or cover guard (see Fig. 113).

Flywheels may also be inclosed by sheet-metal covers in the same manner that belts and pulleys in general are protected.

Rails of one form or another are often used to advantage in machine guarding. Sometimes they are employed in conjunction with cover or inclosure guards for individual parts (see Figs. 114,

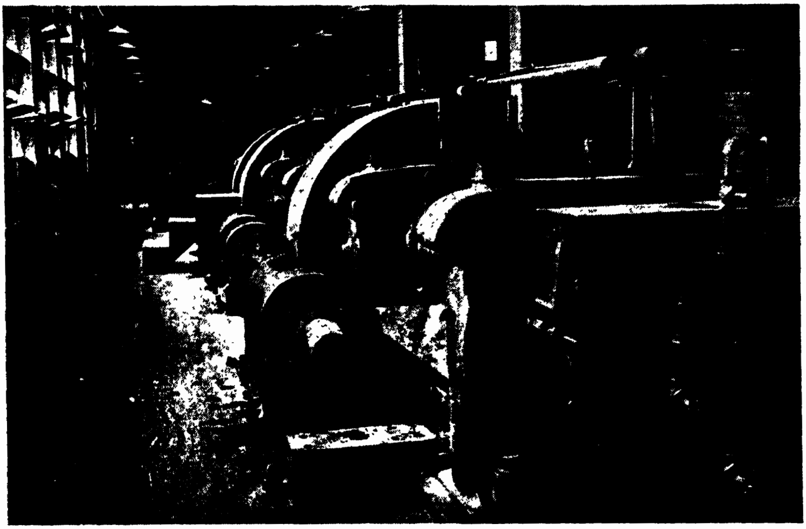


Fig. 108.—Rubber mills with inclosed gears. The ruggedness and simplicity of complete gear inclosures as compared with less perfect protection are well portrayed here.

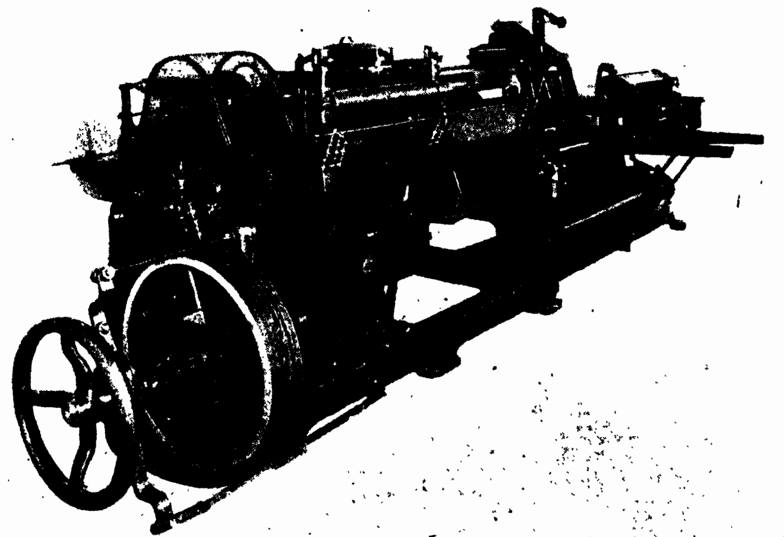


Fig. 109.—Spiral tube winder with wire-mesh gear guards. (*Courtesy of the M. D. Knowlton Company.*)

Guards of the "basket" type are shown over the end gears and the sprocket and chain at the middle.

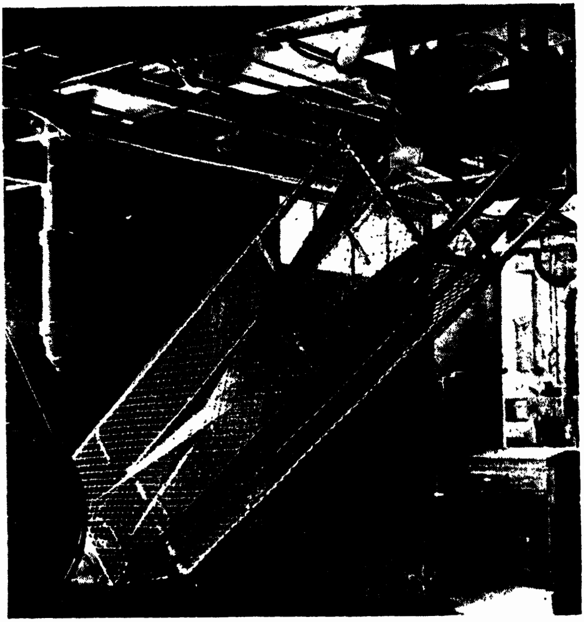


FIG. 110.—Elevator machine with inclosed drive belts.

Heavy wire mesh mounted on iron-pipe framework affords substantial protection for the machine drive belts.

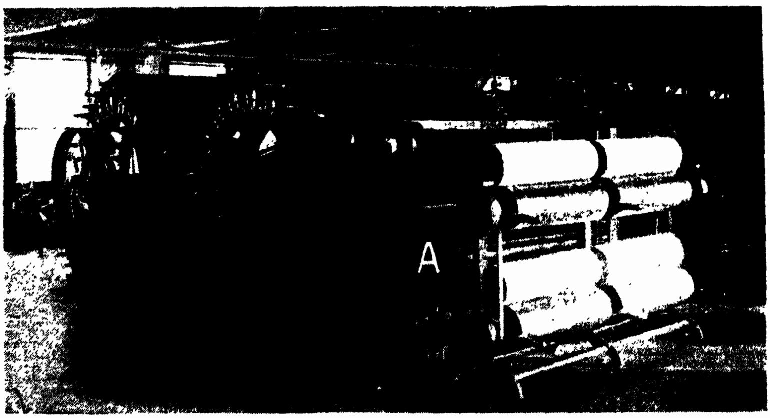


FIG. 111.—Danger points on a woolen card.

Cards have many dangerous exposures because of the large number of belts, pulleys, and gears. These exposures exist on both sides of the machine. A permanent metal guard, shown at *A*, when swung to the left affords protection for a number of small gears. Other exposures are unguarded. See Fig. 112.

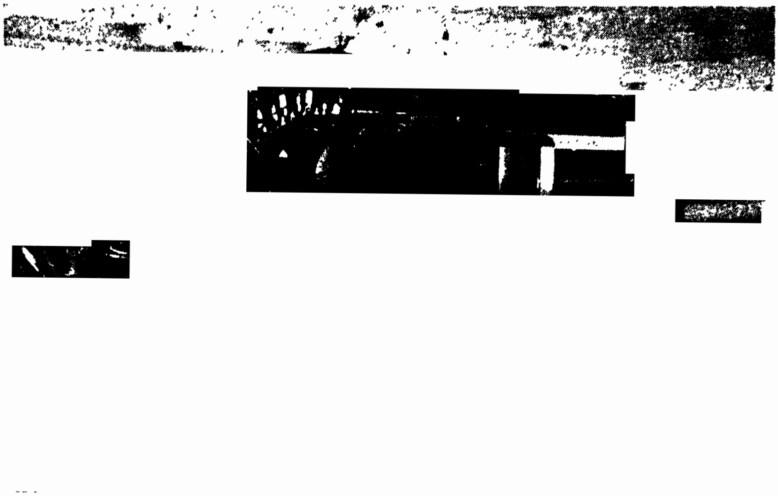


Fig. 112.—Well-designed guards for a woolen card.

When this photograph was taken, the guards had not been entirely completed. The permanent guard at *A* is here shown in the closed position. Compare with Fig. 111.

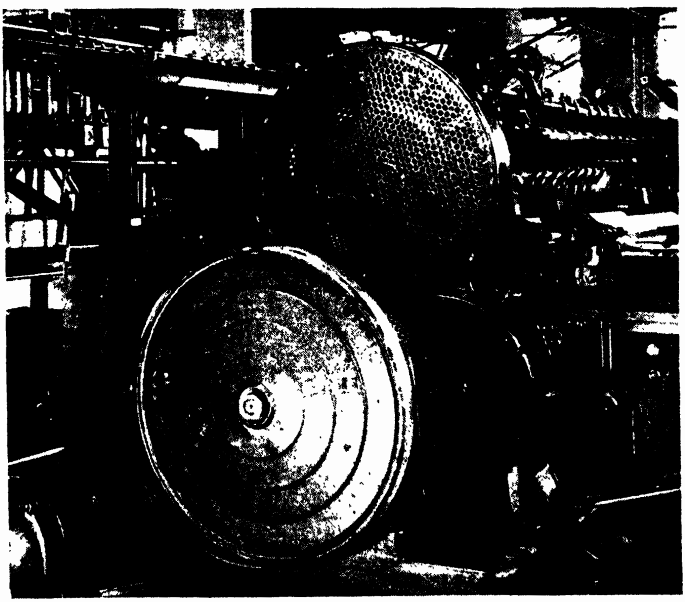


Fig. 113.—Cylinder printing press with blanked balance wheel.

The sheet-steel blank or disk as applied to the balance wheel on this machine has a smooth surface and prevents contact with the revolving spokes.

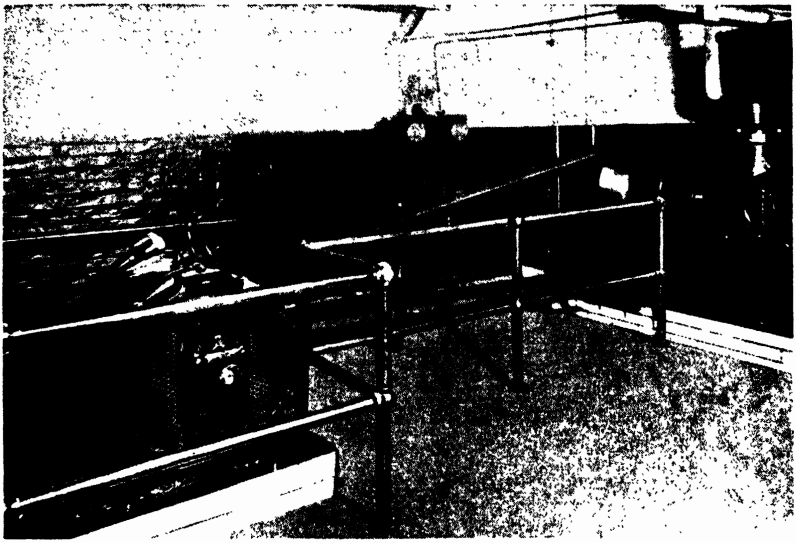


FIG. 114.—Rail guard for compressor drive belt.

This substantially constructed pipe-rail guard provides reasonably good protection. However, there is room for a person between the guard and the belt, and the installation of an individual inclosure in lieu of, or in addition to, the rails would provide greater safety. See Fig. 115.

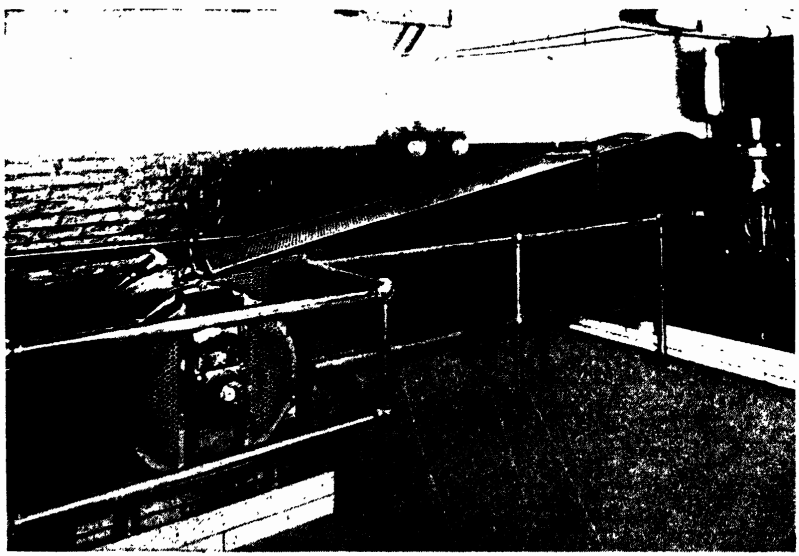


FIG. 115.—Perforated-metal inclosure guard for compressor-drive belt.

A double protection is shown. The rail guard is supplemented by the metal inclosure. The superiority of individual inclosures over rails is shown by contrast with Fig. 114.

115), and with machine design. In general, entire reliance for safety should not be placed on rail guards, if it is possible to apply more complete protection, because the rails must be installed with sufficient clearance (approximately 15 inches under most circumstances) to prevent contact with the moving parts. When installed in this way, however, workmen may enter the inclosed spaced (in fact, it is necessary for them to do this, at times) and thus expose themselves to serious danger.

Safe Location and Arrangement of Machines.—Safe location or arrangement is a "compromise" form of machine guarding.

FIG. 116.—A battery of braiding machines.
The main transmission shaft is so located as to be partially guarded by position. Screen guards are used to close the space at each end.

It is usually defended on grounds of expediency or as a "good enough" method under existing conditions. Motors are often located overhead, with belts leading from them to overhead shafting; electrical equipment is placed behind fences or in locked rooms; machines are so located that the driving mechanism is against the wall; and in many other ways arrangement and location are utilized to obtain greater safety. To be sure, an

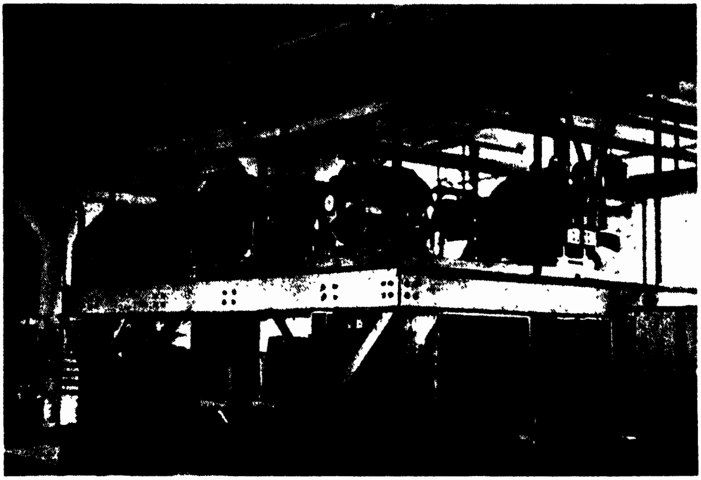


FIG. 117.—Two motor-generator sets located upon an elevated structure.
An example of guarding by location. The bus bars are hung from the ceiling, and accidental contact with them or with the motor-generator sets is improbable.

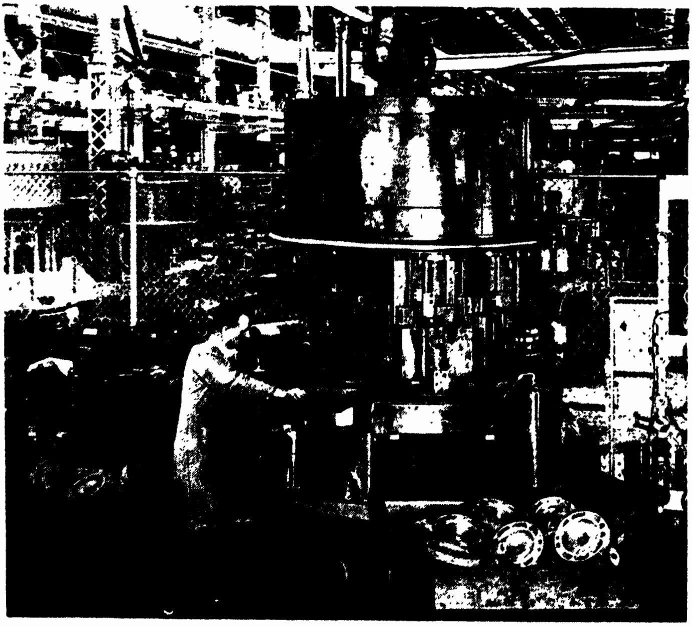


FIG. 118.—Multiple-spindle vertical turret lathe. (*Courtesy of The Bullard Company.*)
The exposed belt at the top of the machine is reasonably well guarded by location.

exposure exists when employees oil this partially guarded machinery, when repairs are made to a part of the equipment while near-by machines are in operation, and when employees are obliged to enter the danger zone for other purposes. Exposure for these reasons, however, may be relatively infrequent, and it is true, therefore, that "guarding by location" has a legitimate place in the consideration of the entire subject (see Figs. 116, 117, 118, 119).

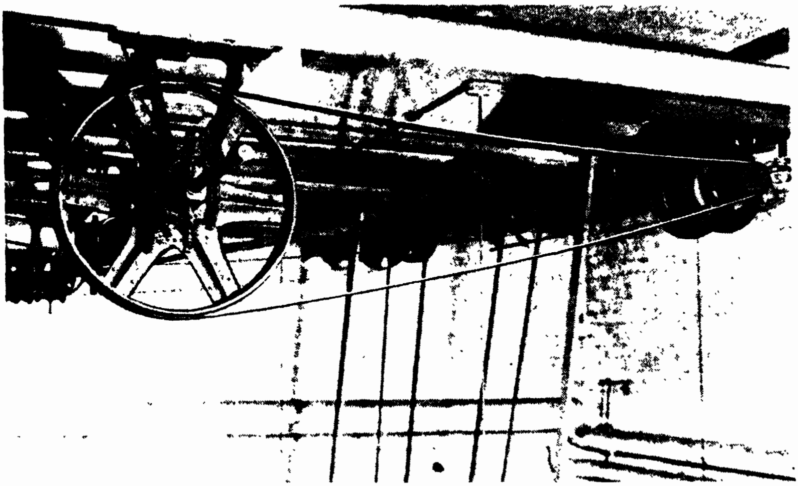


FIG. 119.—Overhead motor transmission belt guarded by location.
The belt is 9 feet from the floor and is guarded by location. The hazard is not entirely removed however. A substantial trough or other form of inclosure is advised.

Incidental Machine Guarding.—One of the incidentals to machine guarding is automatic or centralized lubrication that makes it possible to remain in a safe place while oiling or greasing bearings and friction points.

A common example is the application of centralized lubrication to an industrial manufacturing machine (see Fig. 120), and in the section of this chapter devoted to prime movers and power transmission are other examples of this principle. Consideration of such matters as convenience of operation, height of point-of-operation from the floor or platform, and accessibility for repair and adjustment, and other factors in safe machine design tend to facilitate efficient operation and reduce the accident exposure.[1]

[1] See principles of safe machine design, p. 222.

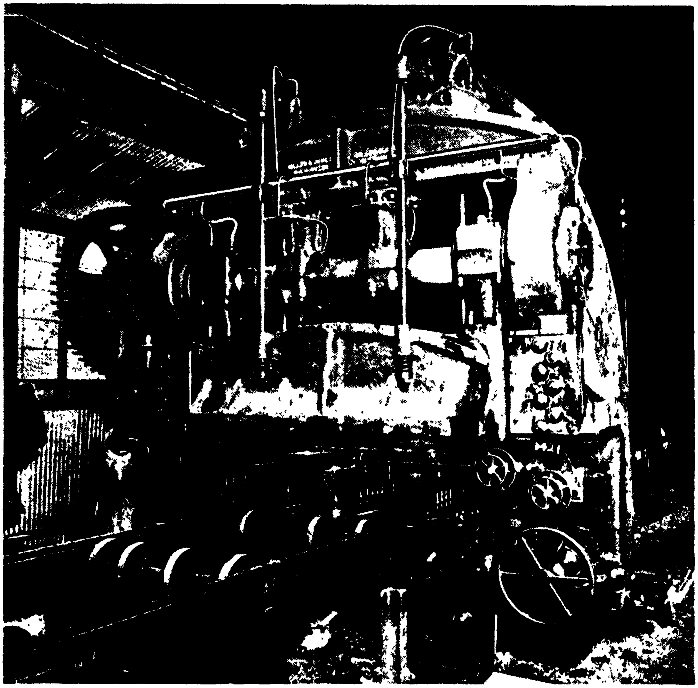


FIG. 120.—A heavy multiple punch with centralized lubrication. (*Courtesy of the Keystone Lubricating Company.*)

This machine is subjected to severe service and high bearing pressures, and it is necessary that lubricant be positively applied to the bearings for proper service and control of maintenance and power costs. Some of the tubes through which the lubricant is forced to the press bearings are shown. The operator or maintenance engineer stands in a safe position when lubrication is applied.

Combination of Several Methods of Guarding Machines.—Machines may be designed with due regard for safe operation; also the principles of inclosing and safe location may be employed when the machines are set up for use. Incidental safeguards may also be applied. A good example is afforded by a safely designed and properly installed traveling crane. Here can be found inclosed machine parts, proper clearances, and such incidental safety devices as overtravel limits, bumpers, warning gongs, and safety hooks.

The text covers merely the principles of machine guarding. The point is made that the work of guarding machines should be guided by knowledge of these principles, that by a process of eliminating one fundamental after another the particular type of guard best suited to the machine is readily selected. The suggestion is also made that machines may best be guarded at the place where they are manufactured and that subsequent guarding, if needed, may be accomplished by applying some of the many forms of covers, inclosures, or barricades, by location and arrangement, by the use of incidental safety devices, or by combinations of guarding methods.

Standards for Machine Guarding.—It is wholly impracticable to quote all the many codes and standards that apply to machine guarding, but the rules given in an appendix[1] are so commonly used that they may serve as a typical illustration.

GUARDING PRIME-MOVER AND TRANSMISSION MECHANISM

The principles that apply to machine guarding (excluding point-of-operation) likewise govern the guarding of prime movers and of transmission shafting, belts, ropes, pulleys, sprockets and chains, clutches, couplings, gears, shaft ends, and projecting, revolving, and reciprocating parts. The hazards of these may be eliminated or minimized by considering:

Design of equipment.
Inclosing, covering, and barricading.
Safe location and arrangement.

Design plays a less important part in guarding transmission equipment than in the protection of machines or the point-of-operation of machines. When machines are not individually driven, it follows that there must be shafts, pulleys, and gears in order that power may be mechanically transmitted to the machine, where it is turned into work, and there is relatively little opportunity for originality in the safe design of such transmission elements. Individual parts, however, are subject to improvement through design, and, in fact, much progress along this line has already been made.

Shaft couplings at one time invariably bristled with projecting bolts and nuts (see Fig. 122). A safer type is now in use (see Fig. 121). The old-fashioned square-head projecting set screw

[1] See Appendix V, "Handbook of Industrial Safety Standards," 1938, National Conservation Bureau.

(see Fig. 123) has been replaced by one that is flush with or below the surface, or by the hollow safety type screw (see Fig. 124).

In minimizing the danger of injury from prime movers and power-transmission equipment, reference may again be made to the present tendency toward the adoption of individual and unit drives. When a motor is close coupled to an individual machine, the arrangement is not a type of guarding in the ordinary sense; yet it is obvious that the exposure from transmission mechanisms is greatly reduced. The section of machine shop shown in Fig.

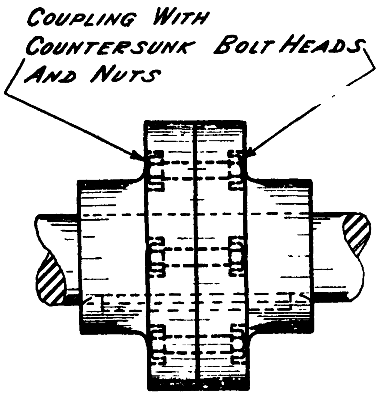


Fig. 121.—Safety type shaft coupling.
Note contrast with projecting bolts on coupling in Fig. 122.

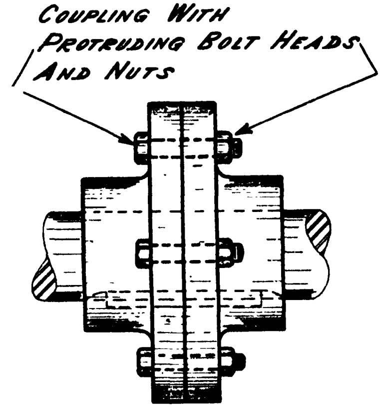


Fig. 122.—Shaft coupling with projecting parts.
Note contrast with smooth contour of coupling in Fig. 121.

125, where the machines are driven from overhead shafting by belts and pulleys, is decidedly more formidable in aspect than a room where the machines are driven by individual motors (see Fig. 126).

The evolution of the shaft-driven sewing machine to individual drive is a notable example of step-by-step progress in the elimination of the objectionable and accident-creating transmission belt, pulley, and shaft (see Figs. 127, 128, 129).

The advance in this direction has been so rapid that it is something of a shock to be confronted with a picture of conditions that existed quite commonly only a few years ago (see Fig. 130) and are even now to be found occasionally.

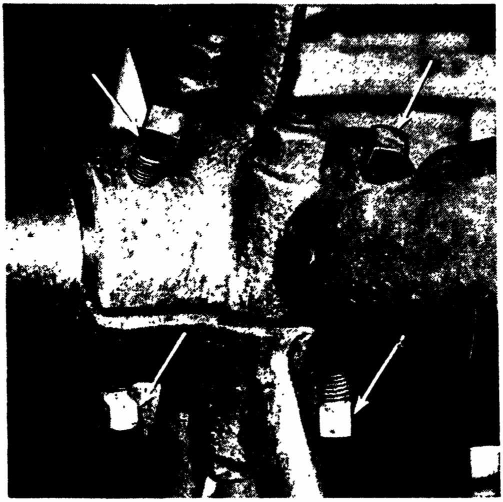


Fig. 123.—Projecting set screws. (*Courtesy of the Allen Manufacturing Company.*)

Compare these set screws with the flush-socket type shown in Fig. 124. Many persons have been whirled to death by catching sleeves or clothing on revolving shafting fitted with projecting set screws.

Fig. 124.—Socket type safety set screws. (*Courtesy of the Allen Manufacturing Company.*)

These screws are driven into position by special hexagonal L wrenches and are set flush with the surface of the pulley hub. Compare with Fig. 123.

FIG. 125.—Machines driven by belts from overhead shafting. (*Courtesy of the Cincinnati Milling Machine Company.*)

Note the many belts and pulleys and the contrast with Fig. 126 which shows similar machines individually driven.

FIG. 126.—Battery of individually driven milling machines. (*Courtesy of the Cincinnati Milling Machine Company.*)

Note absence of belts and pulleys in contrast with Fig. 125.

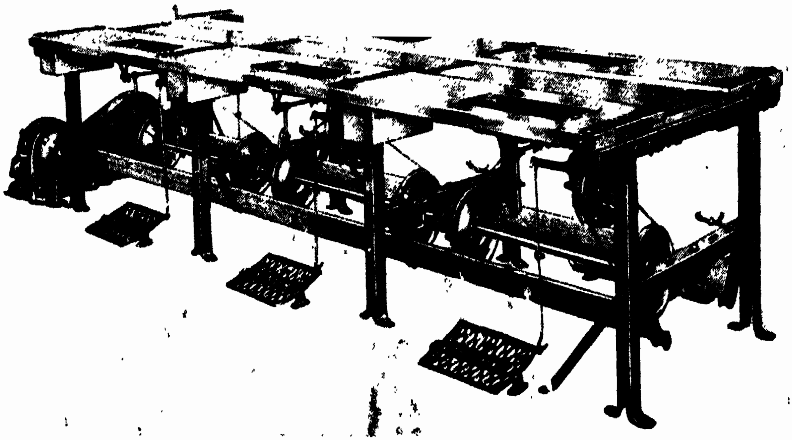


FIG. 127.—Shaft-driven sewing machines with skirtboard guards. (*Courtesy of the Singer Sewing Machine Company.*)

The condition here pictured is much safer than where there is no motor drive at the end of the bench and where even the skirt-boards are absent. The guards, nevertheless, provide scant protection. See Figs. 128, 129.

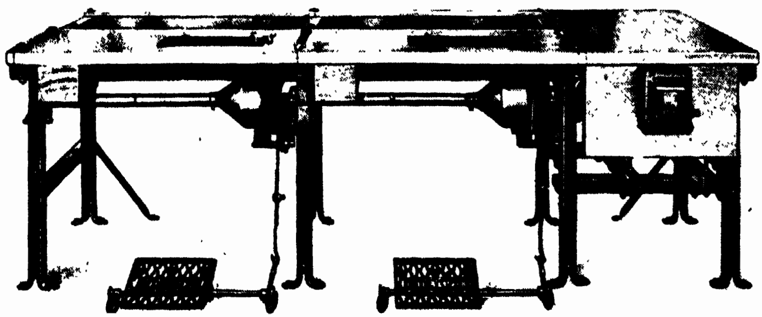


FIG. 128.—Sewing machines with inclosed shafting and drive mechanism. (*Courtesy of the Singer Sewing Machine Company.*)

A step in advance of the guarding methods illustrated by the skirtboards in Fig. 127. The shafting and drive units are solidly inclosed. Safer still is the absence of shafting, as obtained when each machine is individually driven, shown in Fig. 129.

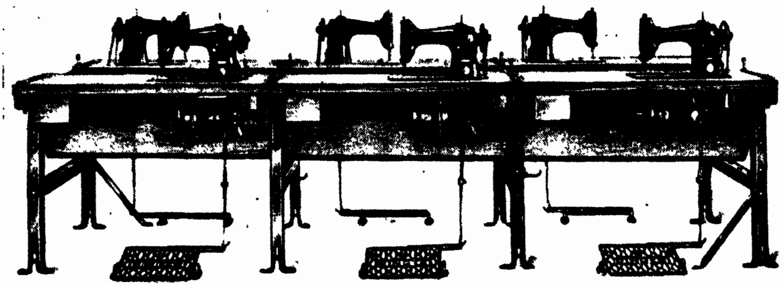


FIG. 129.—Sewing machines driven by individual motors. (*Courtesy of the Singer Sewing Machine Company.*)

Note the absence of shafting, belts and pulleys requiring guards as shown in Figs. 127, 128.

FIG. 130.—A veritable maze of transmission belts and pulleys, also machine belts, pulleys, and moving parts. (*Courtesy of the National Conservation Bureau.*)

The application of individual machine drive would simplify conditions and make them safer. Note that the lighting is adequate and well arranged.

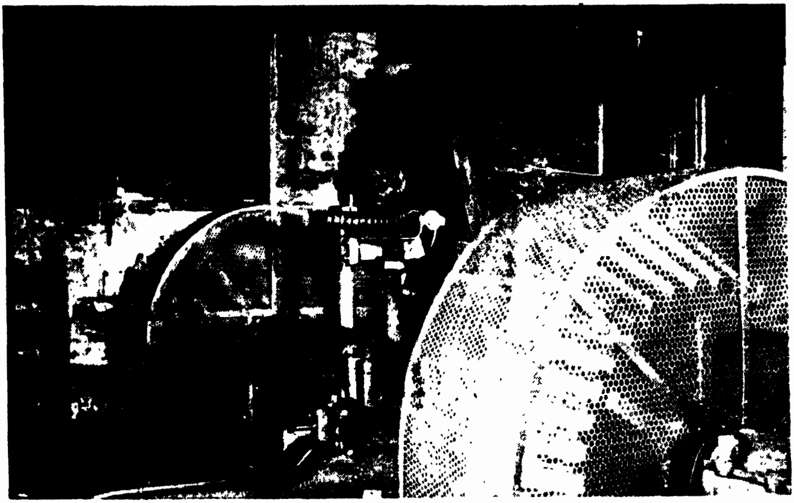


FIG. 131.—Heavy transmission gears with inclosure guards.
Perforated metal on angle iron is used here to good advantage.

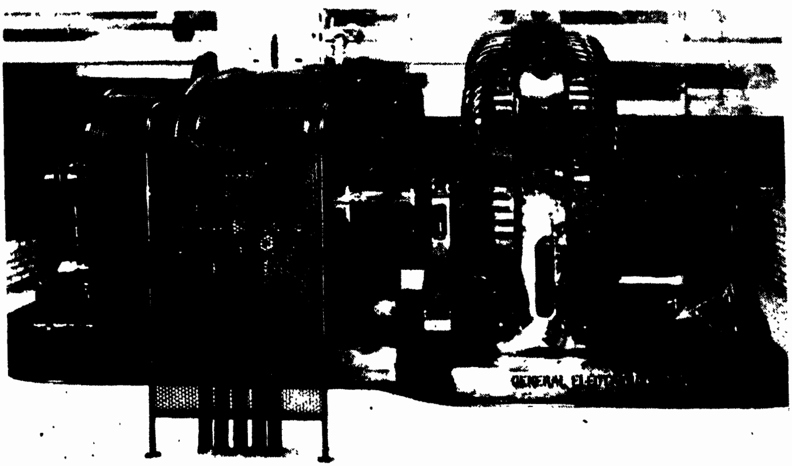


FIG. 132.—A guarded 400-kilowatt motor generator.
A duplicate of this machine is installed directly in the rear of the one here shown. Observe the complete inclosure of all rotating parts and of the electric terminals. The latticework under the motor, indicated by *A*, prevents persons and objects from falling into the pit below. Note the brass cap which covers the end of the motor shaft, shown at the extreme right of the motor.

Inclosing, Covering, or Barricading Prime Movers and Power-transmission Mechanism.—The methods of guarding prime movers and power-transmission equipment by means of inclosures, covers, and barricades and by location are similar to those employed in connection with machines and need but little further description here (see Figs. 131, 132, 133).

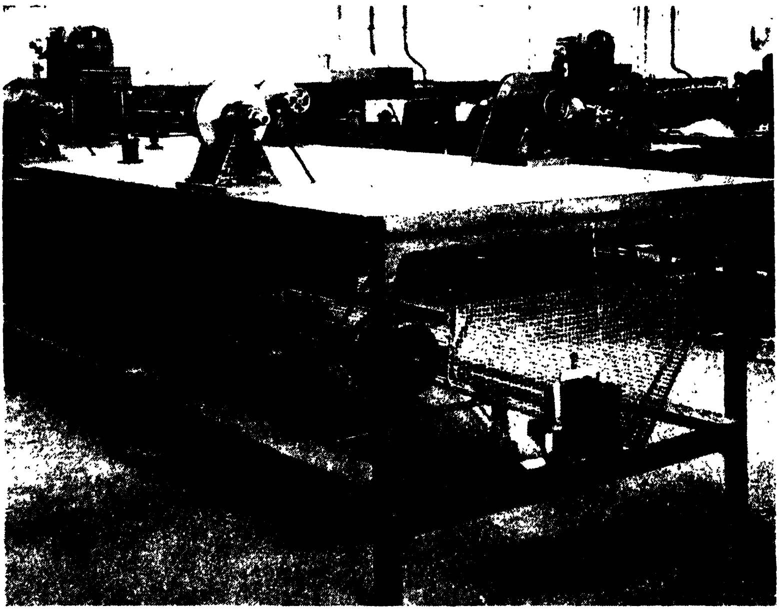


FIG. 133.—Guarded transmission shafting under meter benches. (*Courtesy of the General Electric Company.*)
Note wire-basket inclosure and boxing for the shaft end.

Incidental Safeguarding of Power-transmission Equipment.—Incidental factors in the prevention of accidents on transmissions are indirect or remote lubrication, power-control stations at strategic points, self-lubricated bearings, traveling shaft-polish rings, proper clearances, automatic or mechanical belt shifting, warning signals for starting, and locks on starting devices. The use of these and similar safety accessories reduces the frequency with which workmen are obliged to expose themselves to danger by coming in close proximity to moving parts. Provision for centralized mechanical oiling equipment is a typical example of incidental safeguarding (see Figs. 134, 135).

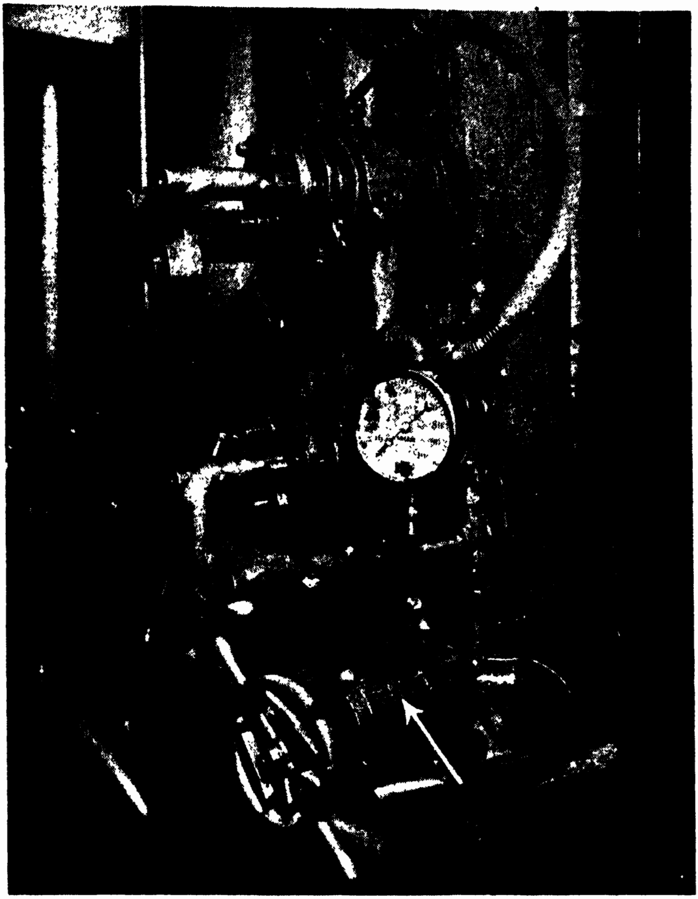


FIG. 134.—Diesel engine with centralized lubrication. (*Courtesy of the Keystone Lubricating Company.*)

The temperature of the cooling water for the upper-piston water-service bearings of this Diesel engine averages 180°F. Before installation of the lubricator, an oil system was used which proved to be wasteful. With the lubricator here shown and the use of a high-melting-point grease, proper service is had at a minimum cost. The arrow points to the lubricator compression unit. The indicator registers the pressure developed. Distributing tubes are also shown.

FIG. 135.—Trolley of an electric traveling crane. (*Courtesy of the Keystone Lubricating Company.*)

All bearings are greased from one point. The lubricator or grease reservoir indicated by the arrow is easy of access. It is unnecessary for the operator or oiler to climb over the unit to reach the various bearings.

Combination of Principles in Guarding Prime Movers and Power-transmission Mechanism.—In the sections of this chapter that relate to machines and to the point-of-operation of machines, the point has been made that practical safeguarding often utilizes two or more principles. This thought is applicable also to prime movers and power-transmission mechanisms. Rail guards are often supplemented by sheet-metal and wire-mesh inclosures; inclosures supplement guarding by location, and incidentals to safety such as centralized lubrication, buffers and bumpers, warning gongs and overtravel limits for the hoists of traveling cranes, are used as additional means of preventing accidents on equipment that is safely designed and on which dangerous moving parts are inclosed.

Standards for Prime Movers and Power-transmission Mechanism.—Requirements or standards that are typical of the rules ordinarily followed for the construction of guards for prime movers and power transmission are given in the Appendix.[1]

[1] See Appendix V, "Handbook of Industrial Safety Standards," 1938, National Conservation Bureau.

SUMMARY

Design and construction of mechanical guards require just as much attention as similar work relating to the machine on which the guard is placed if full benefit is to be derived. Materials should be selected for durability and strength. Design should be such as to accomplish the objective of safety and at the same time fulfill legal or other requirements so that penalties may be avoided and credits secured where possible. When it is not practicable to harmonize these various requirements it is wise to err on the side of safety—in other words, to build the guard high enough or of strong enough materials or with openings of so small a diameter that the most rigid requirements will be fulfilled. Consideration should be given to permanency and to accessibility for repair, replacement, adjustment, and oiling. Metal construction is usually preferable to wood or other combustible material, and inclosures should be avoided that form firetraps or serve to collect dirt or dust in considerable quantity. The guards should fit the machine and be suitable with respect to the operating conditions and all other circumstances. Notwithstanding the fact that man failure causes most industrial accidents, the unguarded machine is potentially dangerous and is far too important to neglect. Mechanical guarding is an accepted and approved practice. It is worth while. Work in this field should be continued, with perfection as the goal, meanwhile striving for greater success in the more profitable zone of attack upon accidents, which lies in the control of man failure.

CHAPTER VII

PROCESS AND PROCEDURE REVISION

One of the most profitable questions that an executive might ask, when applying the principle of cause-analysis to a particular industrial process or procedure that is producing a high and costly accident frequency, is: "Why do the job in this way; why can't it be done in some other and safer way?"

In considering this question, many startling and excellent ideas are often developed, leading, in many cases, not only to safer conditions but also to efficiency and economy.

Examples of Process and Procedure Revision.—The following are typical examples:

Example 1. *Wood-novelty-manufacturing Plant.*—Accidents on and about elevators occurred with troublesome frequency during the transportation of small turned parts from the third floor of one building to the second floor of an adjacent building. These wooden parts were taken from the machines, placed in shallow boxes, piled on trucks, taken to the elevator that carried them to the grade floor, thence across to the elevator in the other building, where they were brought to the polishing department on the second floor. The elevators were slow and small. Traffic was heavy, there was delay and confusion, and accidents occurred when trucks jammed under floor sills, when trays of stock jarred off the trucks, when employees were struck by the semiautomatic elevator gates, and in many other ways, all of which were related to handling, trucking, and elevator operations.

Then the question was asked: "Why can't we handle this job in some other way?" The answer led eventually to the installation of an automatic conveyor system leading directly from one building to the other. Not only was the accident frequency decreased as a result of this change, but, in addition, production was increased, and in this way, as well as because of the smoother and more economical operation that followed, the expense of the new installation was more than paid for.

This example is obviously a very simple one of its class. Phenomenal progress has been made in the field of mechanical conveyors and other apparatus for handling material by the use of mechanical power. There exists today an almost endless variety of chain, belt, bucket, monorail, overhead, and flush-with-the-floor-or-bench conveying apparatus. Lifting and hoisting apparatus is available in the form of simple air hoists, gigantic traveling cranes, escalators and man hoists, trucks that transport and stack or pile heavy material, and cars that carry molten metal distances of 10 miles from cupolas to converters or from converters to foundries. Magnetic hoists are in use for handling scrap and small metal objects, air-blast ducts are used in the textile and other industries, and hydraulic power is employed in lumbering operations to convey logs from the forests to the sawmills. In thousands of ways mechanical power is made available to convey materials more quickly, inexpensively, and safely than could be done by hand labor. If accidents occur during the processing of materials, therefore, it would be wise indeed to ask if the job can be done in some other way.

Example 2. Gear-manufacturing Plant.—In a gear-manufacturing plant small gear blanks, 4 inches in diameter and ½ inch thick, mounted on an arbor 10 in a row, were hobbed at one setting. The burrs that were thrown up on the last gear blank by the tool as it completed its cut caused many injuries. These injuries were aggravated by oil and cutting compounds, and infections resulted. It was considered impracticable for the operators to wear gloves. Tools were kept sharp, yet the burrs still continued to form. No mechanical handling methods were practicable in this case. Attention was therefore given to sterilization of oil, to first-aid facilities, and to the prompt reporting of minor injuries. No real progress was made, however, until again the question: "Why not do the job some other way?" brought a solution. A foreman suggested that 12 gear blanks be mounted on the arbor instead of 10 and that the cut be stopped before completing the gear teeth on the last two blanks. He further recommended that the two unfinished blanks be placed in positions 1 and 2 when starting a new string, and that two new blanks be substituted as Nos. 11 and 12, thus always having stoppers at the end of the arbor, fitting snugly against the last gear (No. 10 in the string) to be completely hobbed, in such manner that burrs could not be thrown up. To assist in lining up the partially hobbed blanks when starting a new string, the foreman devised a simple gauge attached to the index head. The burrs were thus eliminated and so, too, was the burr-removing operation that was previously required. The injury frequency from this cause was practically eliminated. This example points clearly to the fact that in many cases safety may be promoted by employing the ingenuity and mechanical genius of workmen in the average plant in the revision of processes and procedure.

Example 3. *Veneer-manufacturing Plant.*—Three fatalities from scalding and drowning in one year so roused the superintendent of a veneer-manufacturing plant that he determined to take drastic action, if necessary, to bring about safer conditions. The log-soaking vats were the chief source of the trouble. These vats were long and deep, and the temperature of the water was necessarily high. Ordinary precautions had already been taken but had not prevented the fatalities. A heavy concrete curb was built around all sides of each vat. Substantial iron posts were embedded in the concrete, and heavy chains were hung between the posts. Adequate light was provided, and covers were kept in place over the vats at all times when logs were not being taken in or out, and even then, only such sections of the cover as was necessary were removed. But all these precautions apparently did not sufficiently reduce the hazard.

Realizing at last that safety could be attained only through revision of the dangerous method then employed and not through attempts to safeguard that method, the superintendent gave consideration to more radical measures and pondered the question: "Why not do the job some other way?" He learned that a hydraulic crib, or loading and unloading elevator, had been patented. The slatted platform of this apparatus, when in its topmost position, was designed to set nearly flush with the top of the vat, above the water level. Men could place logs on this platform with little danger of falling into the hot water. The platform could then be lowered, more logs put in place, and the process repeated until the vat was full. Unloading was even more simple. By raising the platform clear of the water the logs rolled by gravity to the outside of the vat.

Another safe method that was considered consisted in providing an extra vat that could be loaded *dry*. When it was filled with logs water was pumped in from another storage vat. After the soaking operation had been completed the water was drawn off, and the logs were removed from the dry vat.

The method that was finally adopted after inquiry and experimentation, and which is operating successfully, economically, and safely today, consisted in the use of aboveground soaking sheds heated by low-pressure steam. It had not been thought possible to use steam for the grade of veneer manufactured at this plant, but it was found by trial that this belief was not well founded. The cumbersome hot-water vats were eliminated, and, of course, no more drowning and scalding accidents have since occurred.

Example 4. *Chemical-manufacturing Plant.*—A plant manufactured anthraquinone from crude anthracene imported from Germany. The process necessitated the use of a closed vessel known as a "sublimer." The vapor generated in the sublimer was of an explosive nature, and an explosion occurred of such severity as to direct attention to the desirability of revising the process. In short, the occurrence of accidents in this case again prompted the question: "Why not do the job another and safer way?" and resulted in a beneficial change.

A mechanically agitated fine-wire static collector was placed in the sublimer, and in addition carbon dioxide (an inert gas) was piped from the boiler smokestacks to the vapor space in the sublimer, to neutralize the explosive mixture. Many interesting incidentals were brought to light, including the fact that poisonous mustard gas was generated in the manufacturing process, without the knowledge of the executives and engineers. The revised methods eliminated this unwanted by-product.

Example 5. *Dry-cleaning Plant.*—A dry-cleaning plant had suffered a series of fires and explosions, one of which resulted in loss of life, and the owners were extremely desirous of improving the situation if at all practicable. Processes and methods were studied to find out if some other way of handling the work could be developed that would be safer and equally efficient. This action led to the realization that the use of gasoline or naphtha could be eliminated and that a substitute solvent, having a flash point above 100°F. (about the same as kerosene oil), would do the work equally well and with considerably less hazard. The change was made. The fire and explosive hazards were materially reduced, and the accident record from these causes has subsequently been entirely satisfactory.

Example 6. *Fireworks-manufacturing Plant.*—In the process of making the "fountains" so commonly used in fireworks displays, it was necessary to pierce a small hole in the top (or small end) of each cardboard cone. Awls were used for this operation and, as the result of slipping and improper manipulation, caused many injuries to the hands of the female workers. Careful thought was given to the possibility of performing this operation in some other and safer way. A tool was finally devised that met all requirements. It may be described as a jig or fixture having a lower stationary block containing a sharp piercing tool, and an upper block with a tapered cavity of the approximate shape and dimensions of the small end of the cones, arranged to slide up and down on vertical dowels. Springs were used to return the upper block to position after it had been depressed to the point where the piercing was done. In performing the operation by the new method the cones were inserted in the upper block, pushed down on the piercing tool, and removed. Production was increased, and accidents were eliminated.

Example 7.—The following example of research in engineering revision illustrates a well worth while attempt and is therefore of interest even though it was unsuccessful.

Experience had shown a group of engineers that in certain respects the process of making bread was unsafe. Specifically, many fatal and serious nonfatal injuries had occurred to employees who operated dough mixers. The dough mixers are large barrel-shaped stationary drums in which revolve spiders with heavy mixing arms. In the process of emptying the batch it was customary, sometimes necessary, for the operator to reach through the opened door and detach the dough from the mixing arms *while they were rotating.* In the cases where death or serious injury resulted the men fell in or were caught and drawn into the drums.

Covers interlocked with the operating mechanism were thought of and in fact were applied. However a much more radical idea was developed. It followed the question "Why do the job in this particular way; why not make bread in some other way that does not require mechanical mixing by power-driven mixing arms?" The engineers reasoned that merely because bread had been made from time immemorial by pounding and stretching was not sufficient reason to continue the practice if bread equally as palatable could be made in some other and safer way.

It was found that the purpose of the power dough mixer was not only to mix the flour and water and other ingredients thoroughly but also to develop the glutinous quality of the final product. Substitute mechanical mixing devices of a safer design failed in regard to the last-mentioned purpose, and the attempt was temporarily abandoned.

Under other circumstances the thought given in this instance would have resulted favorably. Had it done so in the case cited the benefits would have been of world-wide extent in that a food staple of universal usage would have been made with less injury to man.

Example 8.—The occurrence of a fatal accident and several serious injuries to the drivers of oil trucks led to the development of safer and better delivery methods in an oil company. It had been the practice to draw off benzol in open five-gallon cans and to deliver the cans to the premises of the purchaser, where the latter emptied the contents into storage drums. The five-gallon cans often were left by the driver on the sidewalk or the entranceway to the premises. The characteristics of benzol are such that the fumes (which are heavier than air and highly combustible) could flow over the tops of the cans, downward and over the entranceway and sidewalk.

Weather conditions—primarily temperature, humidity, and air currents in addition to a source of ignition—were factors in one or more of the accidental cases referred to. However, the practice of drawing off five-gallon lots from the spigot of the multiple-compartment trucks was primarily at fault.

The methods described had been carried on for so many years that they were considered standard and acceptable. The objections to changes in methods were thought to be insurmountable, but, when the fatal accident made the situation acute, the question "Why not do the job some other and safer way?" was considered more seriously.

The remedy in this case was to "package" the benzol in five-gallon cans of the sealed type at the bulk station and to provide storage racks on the delivery trucks. The drivers no longer were required to fill open cans from the truck spigot; they handled none but sealed containers, and the fire and explosion hazards that previously existed were removed.

Example 9.—The occurrence of a serious accident during the process of filling fifty-gallon drums with a caustic liquid prompted the management to consider revising the methods that were in use.

For several years the operation had been performed in the same unsafe way. The drums were placed under the fill tank. The spout was inserted in the bunghole, and the fill valve was opened. Gauging was done visually, and often it was necessary for the operator to remove the spout so that he could see whether the drum was full. Splashing of the contents had frequently occurred, and finally the operator was seriously burned.

It was found that several safer methods were available. Gauging *by weight* instead of by visual examination was practicable. This method permitted the operator to stand at a safe distance. It also ensured greater accuracy and was quicker. A float gauge could also have been inserted in the bunghole so that the level of the liquid could be read directly from the graduated markings on the stem of the gauge. However, the method finally adopted was to use an *automatic* combination-fill-and-shutoff valve.

Accident Prevention Benefits by Invention and Research.—In all these cases insurance service engineers worked in close harmony with the employers. Greater safety was the instigating motive, but, as is generally true in such cases, the objectives of efficiency and economy of operations were associated with that of safety. In countless other cases, research and invention throughout industry, prompted chiefly by the desire for greater volume of product, less expense in manufacturing, more speed, and less inconvenience to the purchasing and using public, have not only brought about these desirable results but have also led to a marked reduction in accidents, in consequence of the replacement of manual operations by machines, and through engineering revision as applied to processes and methods.

The proponents of accident prevention are quick to seize upon and benefit by new developments in the arts and sciences and in the industries generally, and as accident prevention becomes more and more a recognized and firmly established, well-understood, and better planned business procedure, the more it will benefit by the accomplishments in other directions.

The production of corrosion-resisting ferrous metal was of value not only to the manufacturers of cutlery, tools, and equipment of various kinds, which were exposed to conditions causing metallic oxidation, but also in creating a higher factor of safety and increasing the probable life and dependability of certain tools, machine parts, stays, braces, and supports, all exposed to corrosive action and upon which the safety of the operator depends.

The invention of the radio is of value not only for amusement, advertising, instruction, and commercial and private intercommunication, but was also adopted by the aviation industry for the safety of pilots, passengers, public, and the craft, in case of fog or night flying and in daylight flying where safety depends on communication with persons on the ground.

The photoelectric cell has already been adapted to the safeguarding of operators at work upon machines and while engaged in other dangerous operations. Interruption of the rays is made to play a part in preventing or stopping the movement of tools when the hands of the workman come into the danger zone.

The Future.—Still greater accomplishments will be forthcoming, moreover, because the surface of practical possibilities has merely been scratched. The acid test, therefore, should be applied to manufacturing methods that cause accidents, in the realization that these accidents are in a sense an indication of inefficiency; by asking and answering the question: "Why not do the job in another and a better and safer way?"

CHAPTER VIII

SAFETY PSYCHOLOGY

From time to time the point of view of the psychologist has been introduced into the field of practical accident prevention. In certain cases it has influenced active participants in safety work sufficiently to cause them to direct their efforts into psychological channels. Evidence accumulates daily indicating the need of accident-control measures that may be directed toward such bodily or mental conditions as fatigue, worry, unrest, attitude, coordination of muscular and mental faculties, mental and physical reactions, sense of responsibility, improper motive or lack of motive, humanitarian impulses, disposition, age, environment, and other similar factors that serve to influence the action (and often the inaction) that leads to accidents.

Psychology Lies at Root of Sequence of Accident Causes.—The chart of accident causes shown in Chap. II was intended primarily to designate the first proximate real causes of industrial accidents and to direct attention, because of these facts, to the most effective and practicable remedy. In addition, however, the converging cause lines at the top of the chart indicate that all accident causes must, if traced to their origin, emanate from employee or employer fault; indeed, safety psychology is as fairly applicable to the employer as to the employee. The initiative and the chief burden of activity in accident prevention rest upon the employer, but since it would be somewhat visionary to expect the employers themselves to adopt a self-educational point of view, the practical field of effort for prevention through psychology must, temporarily at least, be confined largely to the employee.

Relation of Psychology to Accident Prevention.—Accident prevention may be said to have developed along three distinct lines:

Step 1. Guarding and elimination of machine and physical or material hazards without use of cause-analysis.

Step 2. Selection of remedies based on practical cause-analysis that stops at the selection of the proximate and most easily prevented causes (such procedure is advocated in this book). and considers true psychology when results are not produced by simpler methods.

Step 3. Selection of remedies based on psychological analysis of underlying causes.

Industry in general has not yet taken full advantage of its opportunities in the second step. The ideal situation is one wherein all three steps are taken.

There are two very good reasons in defense of the assertion that action based on the selection of the *first* of the long list of causes (Step 2) reaching into the psychological background, will serve the purposes of industry in most cases to excellent advantage. First, there is the fact that many real causes of accidents are so obvious and so readily corrected that psychological research is hardly necessary. An example is an unsafe act due to "willful disregard of instruction" as illustrated by accidents that occur to employees who, with full knowledge of the hazards involved and of existing safe-practice rules, persist in performing their work in an unsafe way. Without inquiry as to *why* they disregard instruction, it is reasonable to proceed with accident-prevention work in this case by *enforcing* the necessary instructions.

Second, it will be granted that in the small plant or in application to individual employees, widely varying and scattered operations, and where circumstances make it difficult to improve environmental, home, social, or other conditions outside the working places that cause worry, unhappiness, dissatisfaction, unrest, and fatigue, and where expense of investigation is a serious obstacle, applied psychology is not so feasible as a simple common-sense procedure.

In any event, there is no gainsaying the fact that psychology in accident prevention is of great importance. By means of its application the ideal may more rapidly be approached, and even now psychology has proved its value in so many cases as to establish it in the field of approved practice. The third step in the ideal accident-prevention program—psychological analysis of underlying accident causes—is one for which large industries and trade associations should now be laying a solid foundation by means of research. Even though they may not see clearly how the returns from this research are to pay for its cost—which is not trivial if the research is thorough—nevertheless, investigations in this direction are quite as likely to lead to reward in ultimate returns as are expenditures for fundamental research in chemistry. However, it is important to emphasize that this research should not be limited in its objective merely to an inquiry into causes but should have in view the determination of effective remedies.

It is known that some individuals are more prone to accidents than others and that under apparently ideal safe conditions certain persons who are considered unusually careful, thorough, conscientious, skilled, physically fit, and experienced nevertheless act unsafely and receive serious injuries. The cases that follow substantiate this statement and point also to the probable value of psychology in accident prevention.

Psychological Causes of Accidents to Individuals.—The examples given here typify the kinds of accident that direct attention to psychology as a possible solution.

Case 1

A motorbus ran head-on against a "silent policeman" 10 feet high and 4 feet square at its base, which was situated in the middle of a street. As a result of the collision the driver was thrown against the steering wheel and injured. The accident occurred in broad daylight. There was little or no traffic. The driver's attention was not distracted in any way. He was looking directly ahead at the time and stated aferward that he had seen the sentinel, had observed its striking black-and-white markings, and could in no way account for his failure to stop the bus or at least to steer clear of the obstruction.

This was a "struck against" type of accident, and the use of the cause-analysis method advocated in this text resulted in selecting the unsafe act, "failure to maintain proper clearance," and the reason for the unsafe act, "absent-mindedness." These of course are only the first and most readily apparent of a long list of possible causes. The reason for the particular inability was not ascertained. The man may have been an occasional sufferer from psychic epilepsy, in which the patient momentarily loses consciousness without showing any of the usual symptoms of epileptic seizure. The more general identification of the cause of the accident will serve the present purpose of the accident-prevention engineer, however, and the selection of such a cause will eliminate the necessity for considering all other nonapplicable proximate causes, such as defective brakes or other equipment, disobedience or disregard of orders, and others. As a matter of fact, assignment to the causes, failure to maintain proper clearance and absent-mindedness, is a step far in advance of much of the present-day accident analysis that results in the discovery of no cause whatever and which merely indicates a type of accident —such as *collision with fixed object*, or *failure to stop car*. Knowledge of what lay in back of the selected causes would be of still more value, however, and here safety psychology might prove helpful in providing a solution.

Case 2

A certain man who was at all other times a peace-loving, law-abiding citizen—courteous, considerate, and careful to an extreme —became a markedly changed person the moment he sat behind the wheel of his automobile. The sounding of a horn at the rear invariably caused him to "step on it"—it was a challenge that he could not refuse. He "hogged" the road, cut corners, and passed cars on grades and curves. He beat the traffic lights, swore at motorists who impeded his progress, and berated others who insisted on their right of way to his momentary disadvantage. Once in high gear he acted as though gear shifting were a disgrace to his manhood—a shameful act that only dire necessity should countenance between the start of the trip and the final parking place at its end. His state police record disclosed six collisions and two accidents that resulted in personal injury.

What is there about an automobile that has such power over a man? What latent forces are there that find so ready an outlet in the process of driving a car? Psychology may provide an answer for these questions and an effective method for the prevention of certain kinds of automobile accidents, especially those in which the automobiles are owned by commercial organizations and are driven by employees who are subject to supervisory observation and direction. Meanwhile, a practical answer lies in the careful examination of applicants for drivers' licenses; in the thorough reexamination of those who later prove to be unsafe operators; in the promulgation and enforcement of safe-driving laws and restrictive legislation; in general education through the press, the schools, meetings, talks, and pictures; and, of more recent origin, in the force of opinion aroused in a justly indignant public, including not only the pedestrian but the safe and sane motorist as well. Of even more importance is practical cause-analysis as here advocated; namely, identifying and taking corrective action on the pertinent facts of accident occurrence in each case.

Case 3

One of the oldest and most careful and experienced toolmakers in a large specialty machine shop suddenly developed the habit of fumbling and dropping almost every tool or piece of work of which he took hold. He spoiled work that formerly had been accurately done and suffered five injuries in as many weeks. After several weeks of such experience he had his eyes examined, on his own initiative, and also submitted to a thorough physical examination, without, however, finding a solution of his difficulty. All working conditions remained as before, during the period of his reversal of form. Apparently a condition other than one directly related to the work at the plant impaired the ability of the workman to perform safely.

Could safety psychology solve the problem? It would undoubtedly provide interesting and helpful information, but until this is forthcoming it would be unwise to neglect the tools at hand. Analysis conducted as herein advised showed that the type of accident was that of "struck by" tools and materials; the unsafe act, "gripping tools and materials insecurely"; the reason for the unsafe act, "lack of skill," or, more accurately, perhaps, temporary failure to exercise skillfulness; and the remedy, closer supervision by the foreman, consisting in the observation and attempted correction of the many instances of lack of skill in handling tools and materials that, in this case, as well as previously, occurred prior to actual injuries. In practice, this watchfulness, coupled with knowledge on the part of the foreman of exactly what form the employee's lack of skill might be expected to take, prevented further accidents, and after a period of two weeks, the employee again became careful and as skillful as ever.

Case 4

After having caused a number of injuries to himself and others, an experienced employee who had spent many years in general yard work in a small lumberyard discovered that he could perform the work of piling boards safely only when working at the receiving end at the top of the pile. Whenever he stood on the ground and passed the boards up to the man on top, accidents were sure to result. Ordinary job-analysis indicated that practically the same physical requirements, experience, and ability were required for both jobs.

Psychology might reveal certain inhibitions or complexes that would provide an answer to this odd situation. Practical cause-analysis controlled it without any great difficulty, however. It showed that the employee took the first grip on the board at the wrong point, necessitating a shift of grip toward the end of the board, often with resulting injuries from slivers and falls of material; and the remedy—as in the preceding case—closer supervision and repeated warnings while the employee continued at this particular kind of work.

Case 5

Some men who follow the sea for a livelihood, physically perfect specimens as far as medical science can reveal, are known to become seasick on board ship the moment the vessel begins to move and long before it commences to roll and pitch. An old "salt" of the author's acquaintance often became violently nauseated when he heard the anchor chain coming up through the hawse pipe, and when he heard the orders shouted from the bridge to cast off the mooring lines. This man, who was employed as an oiler in the engine room of the vessel, leaned too far over the splash guard in front of the crank pits in the course of his work at sea in calm weather one day and, primarily because of weakness from nausea, lost his balance, fell in, and was killed.

The kind of cause-analysis advocated in this book would not necessarily have revealed the particular combination of physical and mental associations that resulted in the seasickness of this oiler and that psychological study would probably have brought to light. It would, however, show oiling machinery while in an unsafe position and an unfit condition as the practice at fault. From this information the remedy—place the man on less hazardous work or, better still, relieve him from duty until his condition has improved—if applied at the proper time would have prevented the fatality.

Case 6

A young man from a small town, where vision was unobstructed and there were few distractions, came to Boston and secured a position as a messenger for a bank. In walking from the bank to Washington Street on his first assignment, he fell down five times, collided with three hydrants, and sprained his ankle while stepping down from a six-inch curb to the street. Other somewhat similar instances occurred later with considerable frequency until he gave up his position and went back to farming. As best his story could be pieced together, it appeared that his previous environment had been such that he was accustomed to taking long, free, swinging strides in his walk, that the particular type of irregularities and obstacles encountered in the city were totally different from those in the country, that he was bewildered and distracted by the excessive noise and volume of traffic, and for some unknown reason was constitutionally unable to adapt himself readily to the hazards of a metropolitan business life. The application of psychology could perhaps have provided a basic cause and a remedy.

Had accidents of the kind described been frequent enough to make the case one worthy of consideration, the bank officials, even without the assistance of psychological research, by use of the principles of accident prevention that are featured in this book, could have discovered the first of the list of accident causes and could have prevented accident recurrence. By a process of elimination it would have been shown that unguarded or defective mechanical equipment, light, faulty wearing apparel, and unsafe procedure were not at fault; that congestion did exist but that it was normal to city traffic and not controllable anyway, at least by the bank officials; that instruction, discipline, and other moral factors were not at fault; and that, finally, the messenger must have been inattentive. At this point psychology could explain *why* the messenger was inattentive. For the moment it would not be absolutely necessary in this case to go so far. The supervisor under whom the messenger worked would know that he suffered injury because of accidents due to inattention. He would warn him against inattention, caution him to be more alert, and would, when it was evident that no improvement had been made, assign him if practicable to other and safer work.

Psychological Causes of Accidents in Groups of Employees.—In the foregoing cases it has been shown that applied psychology would probably reveal basic causes of accidents to individuals that would remain undetected by other forms of analysis and would undoubtedly direct the way to some method of correcting them. Expense, however, constitutes a limitation when such research is applied in individual cases. The most practical field for safety psychology in accident prevention at the present time lies in its application to groups of employees who are engaged in work of a somewhat standardized character. Of this type are taxicab and bus drivers, motormen of trolley cars, locomotive engineers, salesmen, meter readers, collectors, coal miners, and workmen performing the great variety of common machine and hand operations in the industries that require one employee to perform work of practically the same kind and under the same circumstances as that done by many other workers.

The remarkable results achieved by the Boston Elevated Railway in cooperation with the Personnel Research Federation—Walter V. Bingham, director—provide an excellent illustration[1] of psychology successfully applied to employees who are engaged in the same kind of work. This undertaking was begun in 1927. It was found that 85% of all motormen and bus drivers had an average of 2.3 collisions each and that 15% had an average of 8.2 collisions each. The problem obviously came to a focus on this

[1] Safety on the "El," Boston Elevated Railway, Boston, Mass., 1929.

relatively small proportion of the operators who were not being adequately reached by the usual methods of safety education and supervision.

Basic causes of accident proneness were determined. In some cases these were medical, in some attitudinal, and in others lack of information and training. Treatment was devised to correspond to individual conditions. Assistance, instruction, and advice were given to compensate or to correct lack of abilities, tendencies, and deficiencies. It was not necessary to have recourse to discharge. It was found that only a relatively small proportion of deficiencies were matters of unalterable native endowment.

Among the significant findings of these inquiries, the following were reported in 1927:[1]

1. Men who operate economically tend to operate safely and also to give more satisfactory service.
2. Men with long records of minor delinquencies in car operation tend to have more accidents.
3. Men with abnormal blood pressure had two and one-sixth times as many accidents as other men of the same age and experience.
4. In general, the proportion of accidents decreases steadily and substantially with age, and also with experience, even up to thirty years.

Among the factors studied have been: uncooperative attitude as shown by instances of insubordination or neglect of operating regulations; details of operating habits observed while the man is at work, relations with supervisors and with fellow workers; medical examination data; in some instances, home and family conditions in relation to absent-mindedness, worry, or ill-health; and native aptitude for this work as indicated by performance tests. In general it has been found that there is a significant relationship between accident proneness and various defects that may be grouped roughly under these headings: (1) lack of skill or knowledge, readily corrected through specific instruction and supervision; (2) lack of aptitude; (3) health defect; and (4) defect of personality or attitude, which is also frequently capable

[1] Slocombe, C. S., and W. V. Bingham, "Men Who Have Accidents: Individual Differences among Motormen and Bus Operators of the Boston Elevated Railway," *Personnel Journal*, vol. VI, pp. 251–257, December, 1927.

of cure. Combinations of two or more of these deficiencies are especially serious. If a man is defective in health and also in personality, or in health and aptitude, or in personality and aptitude, his chances of being below the average in his accident record are about 19 out of 20. But even in these instances the man's accident tendencies have often proved to be possible of correction through appropriate methods.

Results in 1927, 1928, 1929, and 1930 were progressively encouraging, until in January, 1930, collision accidents were reduced to less than one-half those for the same month of 1927, and the balance sheet of revenues and operating costs showed a reduction of $300,670.73 in the cost of injuries and damages due to accidents.

Another splendid example of psychological research and prevention of accidents to accident-prone employees is that provided by a railway company in cooperation with the engineers of a life insurance company.[1] Many interesting and valuable conclusions were derived from this study. Some of them are given as follows:

1. Motormen who produce unsatisfactory accident records also tend to consume an excessive amount of power.
2. Fourty-four per cent of all accidents for the period of analysis that was selected for study, occurred to 30 per cent of the employees.
3. Accident-frequency rates tend to decrease with age and experience.
4. Faulty attitude was found to be the principal cause of accident proneness.

Guided by the facts that were developed in this work, suitable action was taken to remove or to counteract the causes of accident proneness. Cases were allocated to three groups: medical problems, personality problems, and faulty-operation problems, and assistance was given as required. The figures and charts in Appendix IV graphically portray the excellent results that were obtained.

Influence of Age upon Accident Frequency.—Experience in accident prevention leaves no room for doubt that age has a decided effect upon the probability of injury among industrial workers. It is not exactly clear just why this should be so, unless it is taken for granted without conclusive data that skill, experi-

[1] Cleveland Railway Company, Cleveland, Ohio, in collaboration with the Metropolitan Life Insurance Company, New York City.

ence, good judgment, and care go hand in hand with age. That such an assumption is not wholly accurate is shown by the fact that thousands of safe workers of mature years are nevertheless "green" or inexperienced in the kind of work they are called upon to do in later years. No matter what the psychological explanation may be, the fact remains that the frequency of accidents to workers is less at older ages. A large industrial state provides interesting and conclusive data on this point.[1] Research in this state, over a 10-year period (1919 to 1928), shows that the frequency of compensable temporary injuries and permanent partial disability injuries, to persons gainfully employed, was highest at ages twenty to twenty-four, somewhat lower at ages eighteen and nineteen, and progressively lower from twenty-four to sixty-five and over. Additional facts concerning the relation of age to accident frequency are given in Appendix VIII.

Although inconclusive because of limited exposure, data are available indicating that the motormen who consume the least electrical current in the operation of trolley cars have the smallest number of accidents; the bus and taxi drivers who get the greatest tire mileage and have a minimum of car repairs are the safe drivers; the machine tenders who get out the most and the best product have fewer accidents; and the employees who handle the most material and handle it the best sustain the lowest frequency of injuries.

It is readily conceivable that this should be so, since efficiency in any line of work requires knowledge, skill, and attention to the job at hand, and because these same factors are essentials likewise in safety.

Extent of Interest in Safety Psychology.—Interesting and instructive advocacy of the application of safety psychology to accident prones appears from many sources. The following quotation is an excellent example:[2]

> Safety engineering has held the field for two decades; it is now the turn of safety psychology.
>
> The chief need of this new science is facts. The usual charges of carelessness or recklessness are ruled out, for these are largely matters

[1] See "Wisconsin Labor Statistics," Industrial Commission of Wisconsin, *Bull.* 25, Mar. 14, 1930.

[2] Free, E. E., "What to Do about Jonah," *Liberty*, Mar. 15, 1930.

of what we call will or intention, and if there is any one firm fact at the bottom of modern scientific psychology, it is that bodily characteristics, instincts, and unconscious mental habits are far more important than conscious intentions.

One way to find out something is to study the hours in a factory during which accidents are most frequent.

During the day shift, most of the accidents occur late in the period of work. During the first two hours of the morning, accidents are few. They increase somewhat between ten and eleven. Between eleven o'clock and noon they reach the forenoon maximum. After the noon hour, accidents are again low for an hour or two. They reach another maximum between four and five o'clock.

The easy assumption is that accidents are increased by fatigue, but they turn out to be related more to the speed of work than to anything else.

The greatest number of accidents to night-shift men occur within two hours after they have gone to work. Thus the four hours before and after suppertime are the dangerous hours of the factory day. They mark the daily peak of excitement, the hours when it is hard to keep one's mind exclusively on the job.

Thus, one new explanation of factory accidents scores to the credit of accident psychology. Another and even weightier score is the explanation of the accident "repeaters,"—Jonahs who are always getting hurt.

Two investigators of the British Industrial Fatigue Research Board, Eric Farmer and E. C. Chambers, are responsible for the solution. The repeater in industrial accidents is merely an individual, they report, who possesses a poor "aestheto-kinetic coordination."

This phrase means no more than our grandmothers meant when they said that somebody's "fingers were all thumbs." This is not exactly awkwardness. It is really a nervous defect, a lack of precise and rapid control of muscular motion by the eye or by other senses.

Mr. Farmer and Mr. Chambers made their chief psychological test on their industrial Jonahs with a strip of perforated paper, like the paper roll of a player piano, passing across a slit in front of the person being tested. This paper had occasional small holes in it. Whenever a hole went past, the person being tested was supposed to stick a little metal pointer through it.

If a person hits every hole that goes by, he has, Mr. Farmer and Mr. Chambers conclude, an exceptional ability to coordinate eye and hand.

The poor Jonahs, on the other hand—individuals shown to be frequent inhabitants of the accident wards—do poorly in this test.

Often it is possible, as Dr. W. V. Bingham recently proved, to educate Jonahs out of part of their bad habits and make them safe.

There is probably no activity which modern industry could support and which would repay support so handsomely. A man subject to accidents endangers everyone around him. The annual losses from the poor innocent Jonahs must reach a staggering sum.

The main thing, really, is that everybody should begin thinking of the problems of accidents, in factories or at home, in terms of the one essential element—the human element.

Research in the field of proneness to accidents has provided much interesting information but has as yet merely scratched the surface of possibilities. In a British publication[1] it is stated in part that:

An investigation carried out by Greenwood and Woods on data collected in munition factories during the war indicates that distribution of accidents is largely influenced by a special personal susceptibility inherent in the individual, and differing from one individual to another. Their report suggests, indeed, that this personal susceptibility may be a far more important factor in accident causation than is generally supposed; for it not only shows by statistical proof that in regard to accidents all workers do not start equal—in that some are more likely to suffer casualties than others—but also affords grounds for thinking that the bulk of accidents may occur amongst a limited number of individuals having a special personal susceptibility to accidents.

In the interests of accident prevention further study of this fundamental question of susceptibility is undoubtedly desirable, since if the importance of special susceptibility as a factor in accident frequency is confirmed, and the qualities which constitute it can be determined, the introduction of some system of selection, on the basis of the accident risk of the work, becomes a practical possibility.

Age may also play a part. Age and inexperience coincide to a large extent, since the majority of new entrants are young people, but irrespectively of this there are certain qualities of youth (such as bravado, failure to realize danger, etc.) which tend to disappear with increasing age. Hence, one would expect to find a proportionately higher accident incidence amongst the younger population of a factory, apart altogether from experience with the work. Information on this point is contained in an analysis of accidents incurred in an American textile mill, from which it appears that the accident rate per 100 workers diminishes from 30 for workers between fifteen and twenty years of age, to 19, 17, and

[1] "Two Contributions to the Study of Accident Causation," *Reports* Industrial Fatigue Research Board, 19, General Series 7.

12 for the next succeeding quinquennial age groups; and an almost identical conclusion has been reached in the case of an investigation in another textile mill. In a large American steel plant, also, in which "the young men were employed along with older men in occupations likely to produce many cases of short-term disability," the accident-frequency rates for workers under twenty was twice that for workers aged twenty to twenty-nine, and more than three times that for workers aged thirty to thirty-nine.

CONCLUSION

There is a vast and practically virgin field of usefulness in applied safety psychology, and it is one that should receive more immediate and widespread consideration. By no means, however, would it be wise to act on the false assumption that safety engineering has outlived its usefulness and that psychology is all that remains. As a matter of fact, a great deal of psychology is an inherent part of properly conducted safety engineering and is applied daily under the guise of better understood terms.

A fair analogy to the substitution of safety psychology for all other accident-prevention work may be taken from the circumstances attending the annual national celebration of the Declaration of Independence.

A fond parent who observes his offspring standing on the back porch with an enormous cannon cracker in one hand and a lighted stick of punk in the other might reason that inherited instincts are at fault and might decide to provide a course of education to overcome them. He might even go so far as to conclude that the attitude of the citizenry in general regarding the manufacture or sale of explosives for noisemaking and fireworks is improper and should be changed. In consequence of this reasoning he might leave the situation on the back porch as described and proceed to organize a public welfare committee, arouse the interest of the town folk, pass resolutions, and assist in the enactment of legislation to prohibit the sale of fireworks for other than authorized persons. The child also might have inherited chance-taking and reckless tendencies, and if this should be shown by psychological research, a way would probably be found to combat them. If the majority of the children in the community possessed the same tendencies, grade-school curricula could well be extended to include studies designed to correct the situation.

To be sure, such action would be defensible on the ground that it would probably cure the situation eventually and that it would make the Fourth of July safer for the entire community, and further, that it would not only eliminate the dangerous cannon cracker and the equally hazardous torpedoes, Roman candles, and other kinds of fireworks but would also teach children to exercise more common sense and caution. If such action only is followed, however, what becomes of the boy who is on the back porch with the cannon cracker in his hand?

In line with the simplified and practical approach to safety as advocated in this text, the boy is unnecessarily exposed to a dangerous object.

Immediate action is necessary, and none could be more effective than to remove the source of danger without delay or to eliminate its harmful possibilities and then to proceed as may be advisable in the effort to remove the underlying causes.

Industry presents a similar problem and one so serious that it constitutes an emergency that requires immediate action. Employees are exposed to mechanical hazards. No matter through whose fault these hazards exist, the best procedure indicates that they should be removed or guarded. Employees are continually being hurt because they do unsafe things or omit to take safety precautions. The immediate practical remedy must be based on knowledge of what these dangerous practices are, why they exist, and on supervisory observation and pressure in correction. If the cause of the unsafe acts, for example, should be willful disregard of instruction, it is not always necessary to find out *why* the instruction is disregarded. It is true that psychological analysis may reveal inability on the part of employees and may indicate that the inability is due to worry or fatigue. Analysis of this nature is admittedly of great value in many cases. Since it is not always necessary to delve so deeply into the origin of accidents, it is clear that for all practical present purposes a line of demarcation may be drawn after the first of the chain of real causes and subcauses has been found. *It is not sufficient, however, in most cases to carry analysis only to the point where the type or the manner of occurrence of the accident is obtained.*

Fundamental analysis invariably directs attention to psychological research when the latter becomes necessary. Suppose that there is a high frequency of accidents in handling material —the specific unsafe act being failure to take a firm two-handed well-balanced grip; the reason, lack of skill. Through good supervision, the employees are frequently checked, warned, reprimanded, instructed, and otherwise directed. If in such a case no progress is made, the natural tendency is to find out why the employees do not react favorably. This rightly directs research to fatigue, home conditions, long hours, frequency of accidents after holidays and early in the morning or just before quitting time, age, and other bodily and mental conditions included in the list of psychological accident factors.

The most important fact, however, is that the first of the long list of probable causes should be ascertained and an attempt made to correct it. This is of special importance because industry today does not yet take full advantage of real cause-analysis; it is, unfortunately, still contented largely with the discovery of accident types—kinds of injuries, hazardous machines, and accident locations; it has not yet absorbed and applied to the full extent the simplified procedures advocated in this text; and it is therefore not yet receptive enough to proceed with the next logical step—which is that of accident psychology.

CHAPTER IX

FATIGUE

Industrial Fatigue.—The relation of fatigue to industrial-accident prevention has been shown in Chap. IV, where it is described as a "personal subcause" or one of the reasons for the unsafe acts of persons. Fatigue is the inevitable result of continued exertion—either mental or muscular. In an endurance test, some persons would work longer than others but, eventually, every one of them would be forced to stop and rest; and, even before the stopping point had been reached, the pace would have slowed down, or the quality of the work would have deteriorated. In addition the person who continues to work while unduly fatigued is not fully alert to the existence of danger, to the precautions that he must take to avoid injury, nor is he as meticulous in his observance of safe-practice rules. Consequently, undue fatigue must be avoided or prevented, not only in order to maintain quantity and quality of production but because of its injurious physical effects on workers.

Causes of Fatigue.—Industrial fatigue has been studied in various countries during the last twenty-five years, and instead of being a rather simple problem, as it was considered originally, it has proved to be an exceedingly complicated one. It is caused, primarily, by continued exertion (not necessarily *over*-exertion). If this were the only cause, the remedy would be obvious—shorter work periods—and, theoretically at least, could be applied easily. There are other important contributory causes or influencing factors, however, that are not so readily apparent. Among them are: the temperature and humidity of workplaces; excessive and continuous noise; the quality and quantity of illumination; the nature of the floor material (as affecting those who must stand while working); and the provision (or lack of it) of suitable chairs for seated workers. These may be called physical factors.

In addition, many workers do not know how to perform their tasks—even simple routine operations—with the least amount of exertion and consequently tire more quickly than they would otherwise.

Various more or less intangible factors may also be mentioned, such as worry about home or financial matters or the possibility of loss of employment, the monotony of repetitive operations, the assignment of workers to tasks for which they may be mentally or physically unfitted, dissatisfaction with working conditions, and other real or fancied grievances. Because of conditions of these kinds, workers may develop a mental attitude toward their work that is more conducive to fatigue than is generally realized.

Tests for Fatigue.—No direct tests for fatigue have been developed that can be applied practicably in industrial plants. There are, however, a number of indirect tests or indexes, including the variation in the amount of output according to the length of the workday, lost time because of sickness, and the frequency of accidents. Output or the amount of work done is considered to be the most reliable of these tests, and British experience during the First World War may be cited as a good example. This showed that increasing the number of working hours per day resulted in greater production at the start, but that the output gradually diminished and eventually fell to a point lower than that which had prevailed when the shorter day was in effect. In addition, there was more lost time because of sickness; and in one munitions plant accident frequency was two and one-half times as great with a 12-hour working day as it was later on when working hours were reduced to 10 per day.

Nightwork.—Many manufacturing plants now are operating on a 24-hour schedule. This may raise the question concerning the relative efficiency of day and night workers and the advisability of continuous nightwork as contrasted with periodical shifts from day to night employment. Some conclusions drawn from British experience are as follows: the output of women employees who shifted alternately from day to nightwork was equal to that of women employed wholly during the day; the production of those employed only at night was from five to ten per cent less than that of those who shifted periodically from daywork to nightwork; changing weekly from day to night employment was better than changing every fortnight.

When the Machine Sets the Pace.—Left to his own devices, a man will work rapidly for a time and then will slow down or will come to a complete stop for a brief period. This method of working is far less tiring than is that of operating a machine that requires continuous labor at a fixed rate—the pace being set by the machine. In this case the resulting fatigue is partly due to the actual physical labor; but the psychological effect also is important—the operator not only is under constant pressure to keep up with or ahead of the machine, but also, in many cases, resents the monotony of the work.

Fatigue and Accidents.—J. R. Garner, M.D., Atlanta, Ga., writing for the Air Hygiene Foundation reports as follows with regard to industrial health defense, "Fatigue in Industry."

Note to Members.—This is the third in a series of short reports for industrial health defense. Purpose of the reports is to point out possible health hazards in this period of stepped-up production and to suggest remedies. No comprehensive treatment is possible in such brief form. Full information is available to member companies upon request.

Industry annually sustains Gargantuan losses directly attributable to fatigue. It is only when we study the insidious ways that fatigue may affect industry, and with its various avenues of entry, that we begin to realize the loss sustained thereby and all too frequently wrongly ascribed to other factors.

What Is Fatigue.—Fatigue is a combined psychological and physiological condition of the cells and organs of the body which have undergone excessive activity with a resulting loss of power. Biologically, there is an accumulation of the so-called "fatigue substances" within the body. This results in lowering of the worker's susceptibility to disease, decreasing his output, increased frequency of errors, and greater liability to personal injuries. Persons with a lowered vitality will exhibit fatigue in a much shorter time than normal individuals. Fatigue invariably leads to a slumping posture which is directly responsible for retarding the respiratory, circulatory, and eliminatory functions of the body and favors accumulation within the body of products normally eliminated, as well as of fatigue substances.

Susceptibility to Disease.—Continued fatigue plays a large and important part in the inception and progress of disease. Those with low physical standards will exhibit fatigue much more readily than healthy persons. The average worker loses 10 days per year from sickness. And losses sustained from general illnesses are 15 times greater than losses due to accidents and occupational diseases.

Decrease in Output.—Recent literature is abundant with studies of decreased output due to fatigue, especially in wartime. Fatigued persons cannot produce as efficiently, regarding both quality and quantity, as those whose muscular and nervous energies have not been so taxed.

Frequency of Errors.—The writer has studied the time of occurrence of errors made by clerical forces and industrial workers engaged in routine and tedious tasks. It was found that as the day advanced errors increased with the maximum occurring just before the close of the day. Obviously, the answer was *fatigue.*

Increased Liability to Personal Injuries.—An article, "Psychology of Accidents," in the *Literary Digest* of Sept. 5, 1931, showed that among 1,300 accidents, 25 per cent were caused, directly or indirectly, by fatigue. Considering that in the United States there occur annually 17,000 deaths, 75,000 permanent disabilities, and 1,400,000 temporary disabilities—a total of approximately a million and one-half injuries—and that one-fourth (25 per cent) of these may be attributable to fatigue, it is easy to realize the enormous drain that fatigue alone makes upon employees and employers. That these stupendous losses admit of a great reduction is obvious. It may not be possible to completely eradicate fatigue from industry, but it certainly can be greatly reduced. Here are eight rules for fatigue reduction:

1. Physical Examinations.—Applicants for employment should be given complete physical examinations. All employees should be given periodic examination.

2. Environments.—Careful attention must be given to our off-the-job surroundings, including home, hygiene, food, relaxation, and entertainment.

3. Diseases.—The periodic reexamination will from time to time bring out the incipiency of some disease which, when detected early, can be either completely eradicated or at least arrested. This prolongs our productive life.

4. Adaptability.—Great care should be exercised in assigning a worker to tasks for which he is adapted. When an employee is found misfitted to his work he should be transferred to some other task.

5. Working Hours.—Adoption of a given number of working hours for all occupations will not always lessen fatigue. Consideration should be given to the amount of routine and monotony connected with the task.

6. Rest Periods.—Rest periods during working hours have been found productive of much good. This is especially true where work is monotonous, confining, etc.

7. Surroundings.—Attention should be given to the working surroundings of employees, especial attention being given to ventilation, light, heat, and noise. All of these play an important role in causing fatigue.

8. Posture.—The Gilbreth International Committee on Industrial Fatigue has conducted extensive studies on industrial seating in connection with fatigue. The committee placed great stress on the harmful effects of improper posture upon the world's industry. They emphasized the importance of adoption and use of chairs constructed along anatomical lines and completely adjusted to the individual worker. Years of experience have proved the use of such chairs to be a material factor in fatigue elimination.

The workman with a fatigued mental, nervous, or muscular system is a "bad risk" for himself and his employer. Remove, or at least minimize, the sources of fatigue and you can radically reduce illness and accidents.

CHAPTER X

OCCUPATIONAL DISEASE

In the prevention of occupational diseases there is the same need for (1) a degree of interest on the part of executives and workers sufficient to initiate and maintain preventive and control methods, (2) the determination of necessary facts, and (3) corrective action based on the facts, as in the case of traumatic injury prevention. The relative importance of man failure as compared to mechanical and physical causes is not so great in the causation of occupational disease as it is in the occurrence of accidents that result in traumatic injury. The facts required for the selection of practical corrective measures in the two kinds of injury differ greatly, and there is likewise a wide variation in the nature of corrective action. In short, there is much difference in detail and technique but none in principle or method.

Recognition of Hazards.—Traumatic injury and its relation to the accident that causes it is obvious inasmuch as the interval of time between the accident and the injury is short. Occupational disease, on the other hand, is not so apparent, nor does it so frequently follow immediately the exposure that is its cause. For these reasons much emphasis is placed upon the necessity for cooperation between physicians and engineers when occupational-disease problems arise. For the same reasons there is great need also for the recognition of specific materials, processes, equipment, and personal performance, one or all of which may bear materially on the incidence of occupational disease. The problem is further complicated by such factors as the susceptibility of the individual and his physical resistance or immunity, lack of complete knowledge relating to the results of exposure to certain materials, slow development of disease in some cases, and nonstandardization of methods for determining the degree of hazard, the threshold danger limits, and often too the methods of control and prevention. In addition, there is considerable variation, from the compensation and legal point of view, in the several states as to the definition of an occupational disease. These complications, however, emphasize rather than minimize the need for a factual and logical approach to the problem such as that here advocated.

Substance or source of occupational disease	Occupational disease associated	Typical industrial operations or uses
Acids (sulphuric, hydrochloric or hydrofluoric).	Poisoning or dermatitis	Acid manufacturing, chemical processing, etc.
Air (compressed)............	Caisson disease	Tunneling
Alkaline compounds (lime, cement, caustics).	Dermatitis	Caustic manufacturing, lime burning, cement making, etc.
Anthrax......	Anthrax	Handling of hides, wool, hair, or bristles
Arsenic.....................	Skin irritation, ulcers, etc.	Insecticide manufacture, etc.
Asbestos..................	Asbestosis	Asbestos mining and milling, manufacture of asbestos products, etc.
Bacterium Mallei............	Glanders	Care and handling of animals
Benzene (benzol) and certain derivatives.	Benzol poisoning	Manufacture and use of solvents
Carbon bisulphide	Acute and chronic poisoning	Rayon industry, rubber, insecticides
Carbon monoxide...........	Carbon monoxide poisoning	Garages, water-gas manufacturing, etc.
Chromium.................	Chrome sores, ulcers	Electroplating, paint manufacturing, tanning
Formaldehyde.......	Respiratory irritation	Plastic and disinfectant manufacturing
Halogenated hydrocarbons...	Skin irritations, liver disorders	Metal degreasing, dry cleaning, refrigerants, flameproofing
Hydrogen sulphide....	Respiratory irritation, conjunctivitis	Rayon industry, metallurgy, sewers
Lead..................	Lead poisoning	Handling and use of lead compounds, storage-battery and paint manufacturing, mining and smelting of lead
Light (glare)...............	Cataract, eye affections	Manufacture of glass, illumination
Manganese..........	Liver ailments, nervous disorders.	Manufacture of alloy steels, in glass industry
Mercury..................	Mercurial poisoning	Manufacture of felt hats, thermometers, germicides, etc.
Methanol (wood alcohol).....	Poisoning of nervous system, especially optic nerve	Antifreeze solutions, varnish making, solvents
Nickel carbonyl............	Irritation and edema of lungs, dermatitis	Antiknock in motor fuel, production of metallic nickel
Nitrous fumes..............	Respiratory irritation and edema	Manufacture of nitrates, welding, handling nitric acid
Petroleum derivatives........	Eye affections, dermatitis, respiratory disorders	Solvents, dry cleaners, paints and varnishes, fuels, lubricants
Phenols...................	Skin irritation	Manufacture and use of disinfectants and preservatives
Phosphorus................	"Phossy jaw" or other bone deterioration	Manufacture of phosphorus and phosphoric acid
Pitch (also tar, bitumen, etc.).	Cancer or ulcer of skin, liver, or eye	Roofing, roadmaking, waterproofing
Radium (or X rays).........	Radium poisoning, tumors, bone decay	Manufacture of luminous paints, dials, radiotherapy, etc.
Silica......................	Silicosis	Granite quarrying, foundries, ore milling, sandblasting, grinding, rock drilling
Zinc......................	Zinc shakes	Zinc smelting, brass foundries

Industry is making amazing progress in the development of new products and new methods. These create new exposures and require new methods of control. Progress is so rapid that at any given time no list of diseases caused by or incidental to industrial occupations or processes can be considered complete. For many reasons, therefore, the foregoing table can be considered only as illustrative of the general problem.

The table on page 290 lists substances or sources of occupational diseases that have been specified in one or more states, typical industrial operations and uses, and the occupational diseases associated with the listed substances or sources.

Creating and Maintaining Interest.—The methods of creating and maintaining interest described in Chap. III are as fully applicable to the prevention of occupational disease as to the prevention of traumatic injury resulting from accidents.

Fact Finding.—Fact finding in the case of occupational-disease prevention is carried on basically in the same way as for traumatic injury. Occupational disease can occur only as the result of the exposure of a person to a mechanical or physical hazard or because of an unsafe personal act. These are the direct and proximate causes of occupational diseases.

Other important and useful facts are as follows:

> The agency, meaning the particular gas, dust, liquid, solid, or other object, material, substance, emanation, etc., that embodies the hazard.
>
> The reason for the unsafe act, meaning the motive or circumstance that prompted the person committing the unsafe act to expose himself or others to danger.
>
> Necessary identification, meaning the particular process or operation involved, the time, place, nature, and extent of injury, etc.

It is significant that the *degree* of hazard in addition to its identification is in a broad sense considerably more important in occupational-disease prevention than is the case with regard to other industrial hazards.

The instruments for determining the contamination in the air are numerous. In the case of dust, such as silica, granite or asbestos, state and federal codes or other enforcement legislation specify the method of the U. S. Department of Public Health. The impinger used in this method is designed to draw the air sample through distilled water and impinge it at high velocity against a submerged glass deflecting plate. The movement of the dust particles is thus momentarily arrested. The air bubbles through the water and escapes through a vent after having left the dust particles entrapped in the water. The dust-containing water is then examined microscopically, and the dust particles are counted. In many cases this method requires considerable time.

Other methods have been devised that employ the principle of air impingement directly on a treated glass plate and examination and counting of the dust under a microscope. Still other methods depend upon electrical or thermal precipitation of the dust from the air for examination. Methods have also been devised for examining the dust directly in the air or for photographing it while it is in the air.

In the case of solvents, the methods of determination are more complicated and depend on the nature of the material. In some cases the material is burned, and the products of combustion are analyzed. In other cases the material is absorbed in a suitable liquid, and its nature and quantity determined later by chemical reaction. Concentrations of combustible vapors can be measured by the combustible gas indicator or by the use of charcoal absorption or the interferometer. It is impossible to go into detail regarding all the methods, but it can be seen from what has been given that determining the extent of industrial contamination of air is a specialized procedure.

Inasmuch as the principles and methods involved in fact finding have already been described in connection with the control of mechanical and personal hazards there is no need for repeating them in this chapter. An example, however, that shows how the pertinent facts of an occupational disease case may be tied in to the headings that are in common use for traumatic injury accidents, may be useful:

FACTS RELATING TO AN OCCUPATIONAL-DISEASE CASE

Description. Employee was repeatedly exposed for a long period of time to the inhalation of dust in sandblast operations. He was provided with a supplied-atmosphere type of respirator and had been warned to adjust it closely around his face but had not done so because, as he stated later, the air supply was inadequate. Silicosis eventually developed.

Agency. Silica dust.
Kind of accident. (Occupational disease) silicosis.
Mechanical or physical cause. Defective respirator equipment. (Inadequate supply of air.)
Performance of person. Failed to use and adjust protective equipment safely.
Personal cause. Improper attitude—not convinced of personal danger.

NOTE.—Attention is directed to the fact that in addition to setting forth the pertinent facts of accident or occupational-disease occurrence as above, it is necessary that thought be given to the relative importance of each fact from the viewpoint of prevention. For example, in this case it was clear that because of the limited knowledge of the employee the *mechanical defect* was much more important than the unsafe act.

Methods of Control.—Technique and detail in the case of occupational-disease prevention vary from the procedures used in connection with traumatic injury. There is, however, the same necessity for consideration and action with regard to methods of control. In the case of occupational disease these may be expressed as follows:

1. Elimination of the injurious substances or sources.
2. Reduction of the original amounts or volumes or frequency of use of the injurious substances or sources.
3. Removal of injurious substances or sources after use.
4. Isolation, guarding, or inclosing of the injurious substances or sources.
5. Control of unsafe personal acts.
6. Provision of personal protective devices.

Typical methods of control for each of the above heads are illustrated by the following examples:

Elimination of the Injurious Substances or Sources.

Example.—Foundry having sandblast equipment discontinued use of sand and substituted steel-shot cleaning methods.

Reduction of the Original Amounts or Volumes or Frequency of Use of the Injurious Substances or Sources.

Example.—In a felt-hat manufacturing plant it was found that only certain kinds of fur required the mercury process. Use of mercury in connection with other furs was discontinued, thus reducing the total amount of the injurious substance as well as its frequency of use.

Removal of Injurious Substances or Sources after Use.

Example.—Control of carbon tetrachloride exposure in a dry-cleaning plant was obtained by vacuum removal of most of carbon tetrachloride vapors before cleaning drums were opened.

Isolation, Guarding, or Inclosing of the Injurious Substances or Sources.

Example.—The "touching up" spray paint process that had been done in the main workshop of a garage was confined to a well-designed booth.

Control of Unsafe Personal Acts.

Example.—Rule was enforced that employees in a battery manufacturing and repair plant wash their hands and faces before eating luncheon.

Provision of Personal Protective Devices.

Example.—Employees exposed to ammonia fumes in an artificial ice plant were provided with gas masks.

The control of occupational-disease hazards is less difficult than is commonly conceived. Any feeling of apprehension as to probable inability to control is due largely to lack of knowledge, first as to the identification and severity of the exposure, and second to the fact that the managerial and supervisory procedures that have proved effective for the control of mechanical and personal hazards that cause traumatic injury accidents are equally effective for those that result in occupational disease.

FIG. 136.—Turbine diaphragm being arc-welded. (*Courtesy of the General Electric Company.*)

Note provision of exhaust system, mask, and gloves.

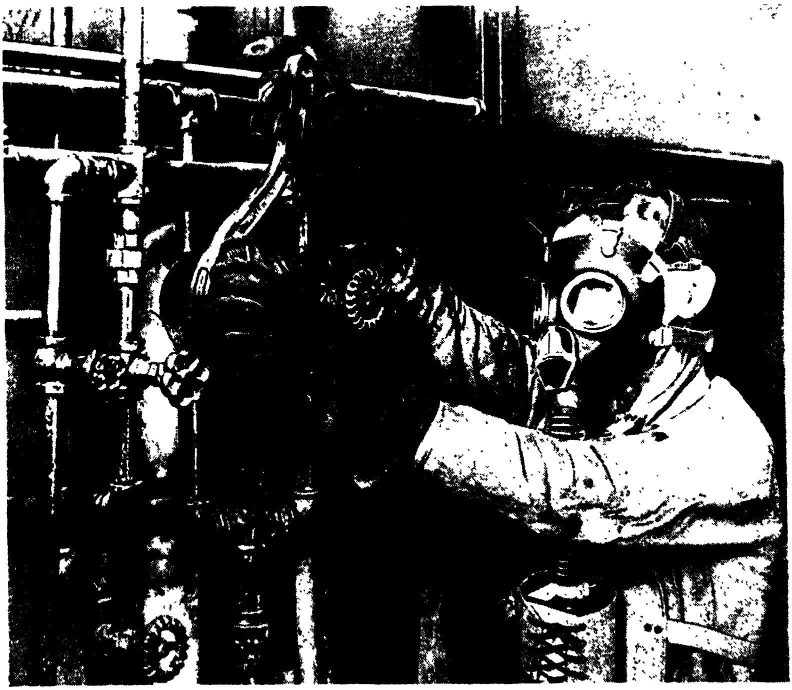


FIG. 137.—M.S.A. Bureau of Mines approved organic-vapor-canister gas mask in use in a chemical plant. (*Courtesy of the National Conservation Bureau.*)

FIG. 138.—Tempering furnace being unloaded—ventilation off. (*Courtesy of Connecticut State Department of Health.*)

Note dispersion of irritating acrolein vapors. See Fig. 139.

FIG. 139.—Tempering furnace being unloaded—ventilation on. (*Courtesy of Connecticut State Department of Health.*)

Note that the exhaust hood and it's connections are attached directly to the front of the furnace. See Fig. 138.

CHAPTER XI

ILLUMINATION

For protection against accident while performing his daily work, the normal person places more reliance on sight than on any of the other senses. The eye, however, can portray to the brain only such impressions as are carried to it by light waves, and if these light waves are insufficient because of poor illumination, the effect on a normal person is similar to that of a condition of partial blindness. Good illumination has long been recognized as a most important factor in industrial-accident prevention, and for this reason progress in illuminating engineering has kept pace in the industries with the advance of general industrial science. The number of accidents fairly attributable to inadequate and otherwise unsuitable illumination is still, however, far greater than is justified by our present knowledge of correct lighting principles and the means of applying them.

Although inadequate illumination is known to be a cause of accidents, the importance of adequate and satisfactory illumination is neither recognized nor appreciated to its full extent. There are millions of violations of the fundamentals of good illumination in our workshops—violations that endanger all workers, regardless of the character of their vision; and millions of workers are laboring every day under the double handicap of poor lighting and subnormal eyesight.

The modern unshaded incandescent lamp, particularly when within the line of vision, is a direct source of glare and therefore represents a violation of good lighting principles. Of the vast number of lamps installed in industrial plants, probably less than 25 per cent are at present equipped with proper reflectors. The remainder either have no reflectors of any kind or are provided merely with those of the obsolete shallow-disk type. It is evident that workers realize the handicap of the unshaded lamp within their range of vision, for there are countless drop lamps shrouded in pieces of brown wrapping paper or newspaper, and not infrequently a 100-watt incandescent lamp with one-half or more of its surface coated with *laundry soap* will be found.

Although it is not the intent of this book to elaborate upon any one accident cause or other factor, it is nevertheless consistent with the text to show the relation between the various factors and the accident-prevention problem as a whole. The principles of proper illumination in the industries are so often neglected, misunderstood, and misapplied that they deserve special consideration from the point of view of their relation to accident cause and control.

Illumination and Accident Prevention.—The relation of illumination to accident prevention is well presented by the following excerpts taken from a paper read at the Grand Rapids Safety Council.[1]

The sense of sight is produced by the coordinated operation of two factors or partners. The first, or physiological, factor is the eye, over which there is practically no control as a visual tool. In case of defective vision the control is limited almost exclusively to supplying artificial lenses, known as "glasses," to assist the natural lenses of the eye in bending light rays so that they will focus on the retina. The second, or external, partner is radiant energy, natural or artificial, within the visible range—that is, light waves of such length as to be perceptible to the eye and which the eye in combination with the brain can transform into the sensation of sight.

The external factor—light, either natural or artificial—can largely be controlled. Sunlight, for example, can be controlled to a considerable extent by shades, prisms, and diffusing glassware; and complete control can be exercised over artificial light, its distribution, diffusion, direction, quality, and quantity, all of which have an important influence on vision. In addition to these, there are four fundamental factors—all of them variable—involved in the ability to see. These are (1) the size of the object, (2) contrast, (3) brightness, and (4) duration of exposure.

Manifestly, the size of an object has considerable influence upon the ability to see it. For example, a football on the floor may be seen under a given degree of illumination, when it would be quite impossible to perceive a match head of the same color as the football.

Contrast may be defined simply, if not with technical accuracy, as the difference in the reflecting qualities of the object and its background.

[1] Simpson, R. E., "Illumination and Accident Prevention," paper read before Grand Rapids Safety Council in Grand Rapids, Mich., May 6, 1930.

This may seem to be a rather academic discussion of relative unimportance, but it all has a bearing, provided the statement is accepted, that illumination is an important factor in accident prevention. The quickness with which danger is perceived and the warning responded to largely determines immunity from accidents or vulnerability to them. It follows, then, that anything that hinders or prevents the endowed senses from giving warning of danger is a contributory cause of the ensuing accident.

Any violation of the fundamental rules of good illumination will have an adverse effect upon the ability to see, because it will handicap the action of the eye. One of the most common violations is insufficiency in the illumination. This usually involves a time element, because whenever there is insufficient light, more time is necessary to see clearly than is required when the illumination is adequate. If the interval between the onset and the climax of an accident-creating condition is half a second, and if the worker, because of poor illumination, requires half a second to see the danger, there is no time left to him for escaping it.

Much has been written about glare, partly because it is so commonly in evidence and partly because it is, perhaps, the most important single condition that adversely affects the ability to see. The most pronounced effect of glare is experienced when gazing directly at the sun. Another common example is the glare from automobile headlights, and more common still is the glare from exposed artificial-light sources lying within the range of vision or from the object viewed or from its background. There are literally millions of cases of such evidence in our industrial plants today, many of them, unfortunately, well within the worker's range of vision.

The bearing that this has, as a cause of accidents, may be gathered by a reference to Fig. 140.[1] It will be noted, first of all, that a standard lighting unit consisting of an incandescent lamp equipped with a steel reflector and a diffusing globe is producing illumination having an intensity of 10 foot-candles on the object shown. Then a bare lamp having a constant-glare value equivalent to reduction of 5 foot-candles is introduced at angles of 5, 10, 20, and 40°, respectively, from the line of vision. Beginning at 40°, such a glare source causes a waste of 42 per cent of the total amount of the light provided, and this increases till at 5° no less than 84 per cent of the light is wasted. By "wasted" is meant that although the intensity of illumination on the object is 10 foot-candles, only 1.6 foot-candles are available for seeing purposes, on account of the effect on the eye of the 5 foot-candle glare. The pupil, the lens, and the retina of the eye are trying to perform two contrary

[1] LUCKIESH and MOSS, "The Science of Seeing." D. Van Nostrand Company, Inc., New York, 1937.

functions at once: (1) to shut out and nullify the effect of the glaring light, and (2) to admit the reflected light from the object and resolve it into vision.

Everyone at all familiar with the interiors of our factories and workshops knows that in the aggregate there are millions of glare sources (bare incandescent lamps) installed in and about the machines and over the workbenches. Probably three-fourths of them are situated so that they are within 10° or less of the line of vision. Likewise, at the majority of these points the illumination is considerably less than 10 foot-candles, and since from 70 to 85 per cent of the light on the

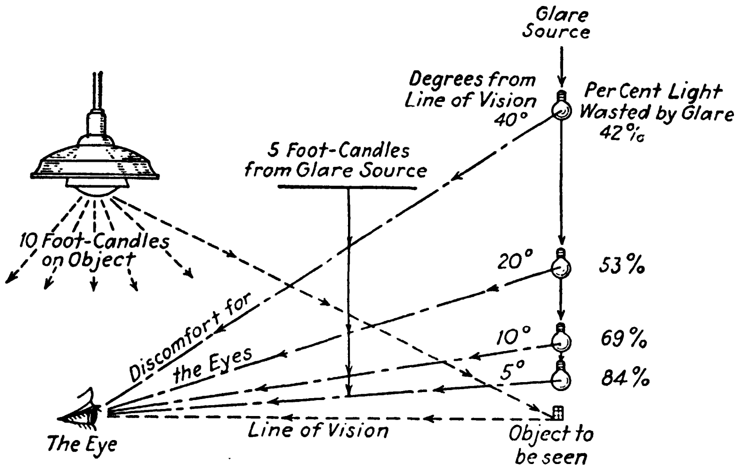


FIG. 140.—The high cost of glare, computed from decreased visibility.

object is unusable because of the glaring lamps, the effective illumination has an actual intensity of only 1 foot-candle.

This, of course, is not conducive to safety or to efficiency, and the situation is made worse by the resulting eyestrain and fatigue, which are quite likely to cause permanent impairment of vision. No matter how narrowly the gaze is fixed or focused, a certain amount of background within the field of vision must be included. The brightness of this background and, to some extent, its area often cause it to be a source of glare. The reflection from brightly polished metals may be as irritating and harmful as the direct light from an exposed bare lamp; and anyone sitting at a desk day after day, and facing even a north window, will be subjecting himself to eyestrain.

A normal eye, aided by good illumination, will assure normal or perfect vision. Any deviation from normal eye condition or from proper illumination must result in subnormal vision accompanied by eyestrain.

If there is any defect in the visual tool (the eye), then that tool must not only work harder to produce satisfactory vision under good illumination but must also exert an even greater effort under poor illumination. Violations of good lighting practice increase the burden on the normal and the subnormal eye. The extra effort inevitably tends to aggravate the defect in the eye—which in turn demands greater exertion. Even with this greater effort, the majority of our industrial workers must often "carry on" with subnormal vision, and insofar as their safety depends upon their sense of sight, they are distinctly handicapped. This condition need not prevail, however, because good illumination is readily obtainable by any and all who want it; and eye defects, other than total loss of sight, may be remedied by competent oculists.

Poor Illumination as a Cause of Accidents.—Accidents from improper or inadequate illumination occur in two ways: First, wherever there is a hazard and the illumination is insufficient to disclose it; second, improper illumination causes eyestrain and eventually brings about a defect in vision, with the result that the ability to see—a most important safeguard even when adequate illumination is provided—is greatly reduced.

Recommended Industrial Lighting Standards.—The industrial safety engineer who wants to know what constitutes minimum operating values in lighting will find the following standards helpful:

RECOMMENDED MINIMUM STANDARDS OF ILLUMINATION FOR INDUSTRIAL INTERIORS*

(Foot-candle values represent order of magnitude rather than exact levels of illumination)

	Minimum Operating Foot-candles Measured on the Work		Minimum Operating Foot-candles Measured on the Work
Aisles, Stairways, Passageways	5	Fine	B†
Assembly:		Extra fine	A†
Rough	10	Automobile manufacturing:	
Medium	20	Assembly line	B†

Attention is called to the fact that the values given are minimum operating values; that is, they apply to measurements of the lighting system in use, not simply when the lamps and reflectors are new and clean—and in almost every instance higher values may be used with greater benefit.

* These standards are taken from "Recommended Practice of Industrial Lighting," published by the Illuminating Engineering Society, 50 Madison Avenue, New York, N. Y.

† See reference footnote at end of table.

RECOMMENDED MINIMUM STANDARDS OF ILLUMINATION FOR INDUSTRIAL INTERIORS.—(*Continued*)

	Minimum Operating Foot-candles Measured on the Work
Frame assembly	15
Body manufacturing:	
Parts	20
Assembly	20
Finishing and inspecting	A†
Bakeries	20
Bookbinding:	
Folding, assembling, pasting, etc	10
Cutting, punching and stitching	20
Embossing	20
Breweries:	
Brew house	5
Boiling, keg washing and filling	10
Bottling	15
Candymaking:	
Box department	20
Chocolate department	
Husking, winnowing, fat extraction, crushing and refining, feeding	10
Bean cleaning and sorting, dipping, packing, wrapping	20
Milling	C†
Cream making:	
Mixing, cooking and molding	20
Gumdrops and jellied forms	20
Hand decorating	C†
Hard candy:	
Mixing, cooking, and molding	20
Die cutting and sorting	C†
Kiss making and wrapping	C†
Canning and preserving	20
Chemical works:	
Hand furnaces, boiling tanks, stationary driers, stationary and gravity crystallizers	5
Mechanical furnaces, generators and stills, mechanical driers, evaporators, filtration, mechanical crystallizers, bleaching	10
Tanks for cooking, extractors, percolators, nitrators, electrolytic cells	15
Clay products and cements:	
Grinding, filter presses, kiln rooms	5
Molding, pressing, cleaning, and trimming	10
Enameling	15
Color and glazing	20
Cleaning and pressing industry:	
Checking and sorting	20

† See reference footnote at end of table.

RECOMMENDED MINIMUM STANDARDS OF ILLUMINATION FOR INDUSTRIAL INTERIORS.—(*Continued*)

	Minimum Operating Foot-candles Measured on the Work
Dry and wet cleaning and steaming	10
Inspection and spotting	A†
Pressing:	
Machine	20
Hand	C†
Receiving and shipping	10
Repair and alteration	C†
Cloth products:	
Cutting, inspecting, sewing:	
Light goods	20
Dark goods	A†
Pressing, cloth treating (oilcloth, etc.)	
Light goods	10
Dark goods	20
Coal tipples and cleaning plants:	
Breaking, screening and cleaning	10
Picking	A†
Construction—indoor:	
General	10
Dairy products	20
Elevators—freight and passenger	10
Engraving	A†
Forge shops and welding	10
Foundries:	
Charging floor, tumbling, cleaning, pouring and shaking out	5
Rough molding and core making	10
Fine molding and core making	20
Garages—automobile:	
Storage—live	10
Storage—dead	2
Repair department and washing	C†
Glass works:	
Mix and furnace rooms, pressing and lehr, glass-blowing machines	10
Grinding, cutting glass to size, silvering	20
Fine grinding, polishing, beveling, etching, and decorating	C, D†
Inspection	B, D†
Glove manufacturing:	
Light goods:	
Pressing, knitting, sorting	10
Cutting, stitching, trimming, and inspecting	20
Dark goods:	
Cutting, pressing, knitting, sorting	20
Stitching, trimming, and inspection	A†
Hangars—airplane:	
Storage—live	10
Repair department	C†

† See reference footnote at end of table.

RECOMMENDED MINIMUM STANDARDS OF ILLUMINATION FOR INDUSTRIAL INTERIORS.—(*Continued*)

	Minimum Operating Foot-candles Measured on the Work
Hat manufacturing:	
Dyeing, stiffening, braiding, cleaning, and refining:	
Light	10
Dark	20
Forming, sizing, pouncing, flanging, finishing, and ironing:	
Light	15
Dark	30
Sewing:	
Light	20
Dark	A†
Ice making—Engine and compressor room	10
Inspection	
Rough	10
Medium	20
Fine	B†
Extra fine	A†
Jewelry and watch manufacturing	A†
Laundries	20
Leather manufacturing‡	
Leather working‡	
Locker rooms	5
Machine shops:	
Rough bench and machine work	10
Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing	20
Fine bench and machine work, fine automatic machines, medium grinding, fine buffing and polishing	B†
Extra fine bench and machine work, grinding—fine work	A†
Meat packing:	
Slaughtering	10
Cleaning, cutting, cooking, grinding, canning, packing	20
Milling—grain foods:	
Cleaning, grinding, and rolling	10
Baking or roasting	20
Flour grading	30
Offices:	
Bookkeeping, typing, and accounting	30
Business machines—power-driven (transcribing and tabulating) calculators, key punch, bookkeeping	B†
Conference room:	
General meetings	0
Office activities—see desk work	
Corridors and stairways	5
Desk work:	
Intermittent reading and writing	20

† See reference footnote at end of table.

‡ An I.E.S. research study of lighting in this industry is now in progress.

Recommended Minimum Standards of Illumination for Industrial Interiors.—(*Continued*)

	Minimum Operating Foot-candles Measured on the Work		Minimum Operating Foot-candles Measured on the Work
Prolonged close work, computing, studying, designing, etc.	C†	Paper-box manufacturing:	
Reading blueprints and plans	30	Light	10
Drafting:		Dark	20
Prolonged close work—art drafting and designing in detail	C†	Storage	5
Rough drawing and sketching	30	Paper manufacturing:	
Filing and index references	20	Beaters, grinding, calendering	10
Lobby	10	Finishing, cutting, trimming, paper-making machines	20
Mail sorting	20	Plating	10
Reception rooms	10	Polishing and burnishing	15
Stenographic work		Power plants, engine room, boilers:	
Prolonged reading shorthand notes	C†	Boilers, coal and ash handling, storage battery rooms	5
Vault	10	Auxiliary equipment, oil switches, and transformers	10
Packing and boxing	10	Engines, generators, blowers, compressors	15
Paint mixing	10	Switchboards	C†
Paint shops:		Printing industries:	
Dipping, simple spraying, firing	10	Type foundries:	
Rubbing, ordinary hand painting and finishing; art, stencil and special spraying	20	Matrix making, dressing type	A†
Fine hand painting and finishing	B†	Font assembly—sorting	B†
Extra fine hand painting and finishing (automobile bodies, piano cases, etc.)	A†	Hand casting	C†
		Machine casting	20
		Printing plants:	
		Presses	C†
		Imposing stones	A†, D†
		Proofreading	A†

† See reference footnote at end of table.

RECOMMENDED MINIMUM STANDARDS OF ILLUMINATION FOR INDUSTRIAL INTERIORS.—(*Continued*)

	Minimum Operating Foot-candles Measured on the Work
Photography:	
Dry plate and film	2,000
Wet plate	3,000
Printing on metal	2,000
Electrotyping:	
Molding, finishing, leveling molds, routing, trimming	B†
Blocking, tinning	C†
Electroplating, washing, backing	20
Photoengraving:	
Etching, staging	20
Blocking	C†
Routing, finishing, proofing	B†
Tint laying	A†
Receiving and shipping	10
Rubber manufacturing and products§	
Sheet-metal works:	
Miscellaneous machines, ordinary benchwork	15
Punches, presses, shears, stamps, welders, spinning, medium benchwork	20, D†
Tin plant inspection	B, D†
Shoe manufacturing (leather):	
Cutting and stitching:	
Cutting tables	10
Marking, buttonholing, skiving, sorting, vamping, and counting:	
Light materials	20
Dark materials	C†
Stitching:	
Light materials	C†
Dark materials	B†
Making and finishing:	
Stitchers, nailers, sole layers, welt beaters and scarfers, trimmers, welters, lasters, edge setters, sluggers, randers, wheelers, treers, cleaning, spraying, buffing, polishing, embossing:	
Light materials	20
Dark materials	C†
Storage, packing, and shipping	10
Shoe manufacturing (rubber):	
Washing, coating, mill run compounding	10
Varnishing, vulcanizing, calendering, upper and sole cutting	C†
Sole rolling, lining, making and finishing processes	C†

† See reference footnote at end of table.

§ An I.E.A. research study of lighting in this industry is now in progress

Recommended Minimum Standards of Illumination for Industrial Interiors.—(*Continued*)

	Minimum Operating Foot-candles Measured on the Work
Soap manufacturing:	
Kettle houses, cutting, soap chip and powder	10
Stamping, wrapping and packing, filling, and packing soap powder	20
Steel and iron manufacturing:	
Billet, blooming, sheet bar, skelp and slabbing mills	5
Boiler room, power house, foundry and furnace rooms	5
Hot sheet and hot strip mills	10
Cold strip, pipe, rail, rod, tube, universal plate and wire drawing	10‖
Merchant and sheared plate mills	15‖
Tin plate mills:	
Hot strip rolling and tinning machine department	10
Cold strip rolling	15
Inspection:	
Black plate	C†
Bloom and billet chipping	C†
Tin plate and other bright surfaces	B, D†
Machine shops and maintenance department	
Repair shops:	
Rough bench and machine work	10
Medium bench and machine work	20
Fine work—buffing, polishing, etc	B†
Extra fine work	A†
Blacksmith shop	10
Laboratories (chemical and physical)	15
Carpenter and pattern shop	20
Storage	2
Stone crushing and screening:	
Belt conveyor tubes, main line shafting spaces, chute rooms, inside of bins	5
Primary breaker room, auxiliary breakers under bins	5
Screens	10
Storage-battery manufacturing:	
Molding of grids	10
Store and stock rooms:	
Rough bulky material	5

† See reference footnote at end of table.

‖ In these areas many of the machines require one or more supplementary lighting units mounted on them in order to direct light effectively toward the working points.

Recommended Minimum Standards of Illumination for Industrial Interiors.—(*Continued*)

	Minimum Operating Foot-candles Measured on the Work
Medium or fine material requiring care	10
Structural steel fabrication	10
Sugar grading	30
Testing:	
Rough	10
Fine	20
Extra fine instruments, scales, etc.	A†
Textile mills:	
Cotton:	
Opening, mixing, picking, carding, and drawing	10
Slubbing, roving, spinning	20
Spooling, warping on comb	20
Beaming and slashing on comb	
Gray goods	20
Denims	B†
Inspection:	
Gray goods (hand turning)	C†
Denims (rapidly moving)	A†
Automatic tying-in, weaving	B†
Drawing-in by hand	A†
Silk and rayon manufacturing:	
Soaking, fugitive tinting, and conditioning or setting of twist	10
Winding, twisting, rewinding, and coning, quilling, slashing	30
Warping (silk or cotton system) on creel, on running ends, on reel, on beam, on warp at beaming	C†
Drawing-in:	
On heddles	A†
On reed	A†
Weaving:	
On heddles and reeds	5
On warp back of harness	10
On woven cloth	30
Woolen:	
Carding, picking, washing, combing	10
Twisting, dyeing	10
Drawing-in, warping:	
Light goods	15
Dark goods	30
Weaving:	
Light goods	15
Dark goods	30
Knitting machines	20
Tobacco products:	
Drying, stripping, general	10
Grading and sorting	A†
Toilets and washrooms	5
Upholstering—automobile, coach furniture	20
Warehouse	5

† See reference footnote at end of table.

Recommended Minimum Standards of Illumination for Industrial Interiors.—(*Continued*)

	Minimum Operating Foot-candles Measured on the Work
Woodworking:	
Rough sawing and benchwork.......	10
Sizing, planing, rough sanding, medium machine and bench work, gluing, veneering, cooperage	20
Fine bench and machine work, fine sanding and finishing..............	C†

† Lighting recommendations for the more difficult seeing tasks, as indicated by A, B, C, and D in the foregoing table, are given in the following:

Group A.—These seeing tasks involve (*a*) the discrimination of extremely fine detail under conditions of (*b*) extremely poor contrast, (*c*) for long periods of time. To meet these requirements, illumination levels above 100 foot-candles are recommended.

To provide illumination of this order a combination of at least 20 foot-candles of general lighting plus specialized supplementary lighting is necessary. The design and installation of the combination systems must not only provide a sufficient amount of light but also must provide the proper direction of light, diffusion, eye protection, and insofar as possible must eliminate direct and reflected glare as well as objectionable shadows.

Group B.—This group of visual tasks involves (*a*) the discrimination of fine detail under conditions of (*b*) a fair degree of contrast (*c*) for long periods of time. Illumination levels from 50 to 100 foot-candles are required.

To provide illumination of this order a combination of 10 to 20 foot-candles of general lighting plus specialized supplementary lighting is necessary. The design and installation of the combination systems must provide not only a sufficient amount of light but also the proper direction of light diffusion, eye protection, and insofar as possible must eliminate direct and reflected glare as well as objectionable shadows.

Group C.—The seeing tasks in this group involve (*a*) the discrimination of moderately fine detail under conditions of (*b*) better than average contrast (*c*) for intermittent periods of time.

The level of illumination required is of the order of 30 to 50 foot-candles, and in some instances it may be provided from a general lighting system. Oftentimes, however, it will be found more economical and yet equally satisfactory to provide from 10 to 20 foot-candles from the general system and the remainder from specialized supplementary lighting. The design and installation of the combination systems must provide not only a sufficient amount of light but also the proper direction of light, diffusion, eye protection, and insofar as possible must eliminate direct and reflected glare as well as objectionable shadows.

Group D.—The seeing tasks of this group require the discrimination of fine detail by utilizing (*a*) the reflected image of a luminous area or (*b*) the transmitted light from a luminous area.

The essential requirements are (1) that the luminous area shall be large enough to cover the surface that is being inspected and (2) that the brightness be within the limits necessary to obtain comfortable contrast conditions. This involves the use of sources of large area and relatively low brightness in which the source brightness is the principal factor rather than the foot-candles produced at a given point.

New Light Sources.—Of the several varieties of relatively new light sources, the fluorescent lamp has attracted much attention. Developed at first for supplementary lighting, it is now available in the larger sizes for the field of general lighting. The fluorescent lamp produces both daylight and colored light at high efficiencies and at low operating temperatures. The last-named characteristic has led to the use of the expression "cold light." Several of the features of the fluorescent lamp bear directly on the prevention of accidents, namely:

1. Higher over-all efficiency, which encourages the provision of a more adequate amount of light.
2. Improved quality of light more closely approaching daylight.
3. Less sensitivity to voltage fluctuations that should tend to decrease eyestrain.
4. Lower temperatures that permit a greater degree of comfort where persons must work close to the light source.

In a Chicago manufacturing plant numerous complaints of eyestrain were made by the employees. After fluorescent illumination, with an intensity of 35 to 40 foot-candles, was provided, production was stepped up, inspection of parts became more accurate, and employees were much more satisfied. The close relation that generally exists between physical comfort and efficiency on the one hand and safety on the other leads to the conclusion that an improvement in accident experience may also be expected. Figures 141 and 142 are typical of the "before-and-after" situations in this plant.

Additional illustrations of fluorescent lighting show modern applications. In Fig. 143 the lamps are placed 52 inches from the top of the tables and provide 45 foot-candles under the centers of the lamps. In Fig. 144 the lamps are set 8 feet above the floor and provide 40 foot-candles at the working level.

Common Errors in Industrial Illumination.—It is worth repeating that "safety begins with a clean, light, well-guarded and orderly working environment." This is a fundamental truth, and it is applicable even though it still remains true that the most effective attack on the accident problem requires an understanding of the science of prevention as outlined in this text. Whether poor light is or is not the most prolific accident

FIG. 141.—Before fluorescent lighting. (*Courtesy of the Howard B. Jones Company.*)

FIG. 142.—After fluorescent lighting. (*Courtesy of the Howard B. Jones Company.*)

FIG. 143.—Well-arranged fluorescent lighting. (*Courtesy of Boris Smoler & Sons.*)

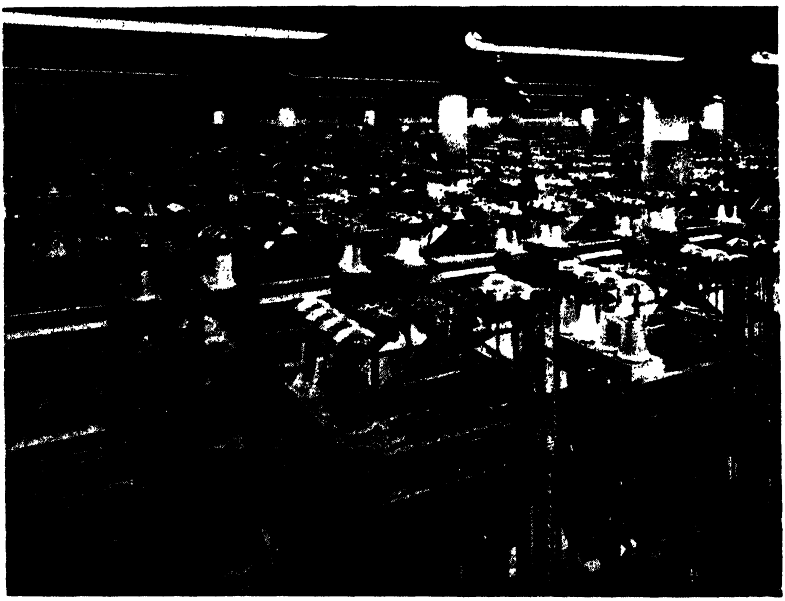


FIG. 144.—Modern lighting in a hosiery mill. (*Courtesy of the Dexdale Hosiery Mills.*)

breeder, common sense dictates that light nevertheless should be adequate.

Even after a plant or other industrial operation has been suitably lighted, it is well to keep in mind that unsatisfactory situations may develop unnoticed unless periodical check is made.

Such checks may be directed with profit to:

1. The amount of light.
2. Uniformity.
3. Shadows and spotty local lighting.
4. Shielding of bulbs and glare.
5. Proper type of reflectors.
6. Maintenance.
7. Operation of lamps at rated voltage.
8. Breakage and explosion conditions.

Medical Viewpoint on Illumination.—In an address before the Greater New York Safety Conference, Le Grand H. Hardy, M. D.,[1] states:

In summarizing, the following points may be made regarding illumination and defective vision in relation to accidents in industry:

1. Defective illumination is a common and expensive cause of defective eyesight and accidents.

2. The major lighting defects may easily be recognized and in most cases eradicated.

3. The eradication of defective illumination is usually not only practically possible but economically profitable.

4. The best available statistics indicate that about 40 per cent of our industrial workers have defective vision due to ocular defects.

5. This number is probably being increased by unhygienic lighting conditions; and poor illumination augments the ocular deficiencies already present.

6. Refractive errors cause potentially dangerous situations by producing fatigue, reducing physical efficiency, and failing to give adequate warning of danger while there is yet time to avoid it.

7. Muscle imbalances lower the worker's resistance to fatigue and disturb his quick and accurate spatial perceptions which are essential to safe behavior among moving objects.

8. Organic diseases not only reduce vision, both central and peripheral, but by causing distortions, blind spots, illusions, etc., handicap the worker's control of his physical activities.

[1] Le Grand H. Hardy, M.D., director of eye service, Fifth Avenue Hospital, New York, N. Y.

CHAPTER XII

SAFETY ORGANIZATION—FIRST AID AND HOSPITAL

Organized industrial accident-prevention work constitutes the vehicle—the means of procedure—by which safety activities are correlated and directed. The plant safety organization is a "clearing house." The expression has a broader significance than merely the inclusion of safety committees, safety inspectors, safety meetings, and other similar detail. It includes the interest, support, direction, and participation of the higher executives, the application of effective procedures, and the provision of adequate first-aid, medical, and hospital facilities. As such, its nature and scope are governed by the principles of accident prevention as here described, which remain fixed regardless of the safety organizational requirements of individual plants.

It has already been stated that the prevention of accidents is directly accomplished by finding the unsafe practices of persons and correcting them by procedure based on the reasons why they exist, and by correcting mechanical and physical hazards. This would seem to make safety organizations unnecessary. In fact, it does so, provided that effective means are found to accomplish the desired objectives in some other way. In actual practice, however, it has been found that the simple and direct measures mentioned are best undertaken when at least the practical minimum of regularly conducted safety procedure is utilized. Thus safety organization in one form or another, whether it be so called or otherwise designated, is a defensible and necessary working tool. Finally, it must be granted that the *basic elements*, at least, of organized safety must exist wherever accident frequency and severity are kept under control.

Basic Elements of Organized Safety.

1. Periodical inspections or surveys of structures, machines, tools, equipment, processes, and employee procedures.
2. Accident investigation for the determination of causal facts.
3. Corrective action with regard to the unsafe practices and mechanical hazards disclosed by 1 and 2.

The above list includes the basic or inescapable elements of organized safety work. They apply to even the smallest industrial plant or operation. If a plant is of such small size that the owner or employer must also be the superintendent and foreman, then he must be the plant safety inspector as well and must also investigate accidents and take necessary corrective action. In short, he must be the "whole works" in safety work just as he is in supervising the quality, volume, and cost of production. In such a case the amount of detail in conducting safety work systematically is, of course, comparatively limited.

In the case of larger industrial organizations, although the same elemental procedures exist, there must be a delegation of executive and supervisory authority coupled with a like delegation of responsibility for carrying on the work. In addition, the formation of committees and subcommittees becomes necessary. Personnel safety work is given to one supervisor and mechanical guarding to another. Refinements and detail become justifiable. The facts of accident occurrence and accident prevention are too numerous to be kept in mind readily and must therefore be recorded. This leads to the development of forms, routines for handling forms, and clerical procedures. In all such work, however, even including the most detailed and complex safety organizations, the basics remain as first described.

Typical Outline of Safety Organization for a Large Plant.—The safety-organization plan described hereunder is that adopted by a metal-goods manufacturing concern employing 1,000 workers in a single building. The plan has worked effectively over a period of several years, and it is sufficiently typical of current sound and progressive practice to justify its inclusion as an example of recommended procedure.

PLAN FOR THE PREVENTION OF ACCIDENTS

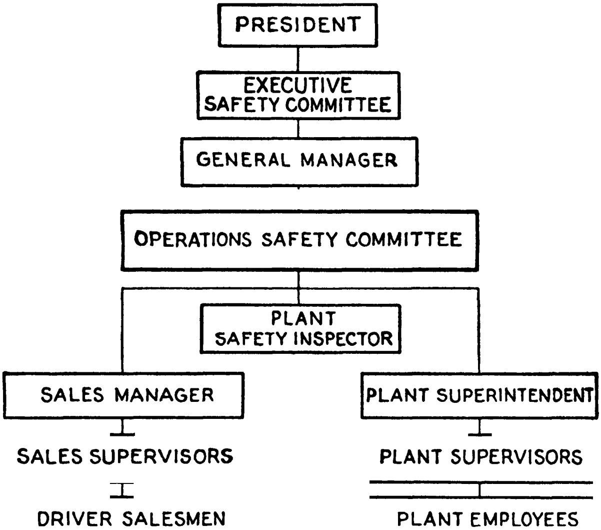


FIG. 145.—Personnel chart for safety organization.

Executive Direction.—The executive direction, in general, of accident prevention in all of its phases shall be the responsibility of the executive safety committee, the chairman of which shall report directly to the president.

1. Membership shall consist of the president's designated representative, the general manager, the plant superintendent, and the sales manager.
2. Meetings shall be held the first week of each month, or more frequently as ordered by the president or as required by special circumstances.
3. A secretary shall be appointed whose duty shall be to prepare the agenda, provide necessary exhibits and factual material for consideration and discussion, and record the minutes.
4. Specific responsibilities and activities of the executive safety committee shall include:

   a. Review of and action on the reports and recommendations of the operations safety committee.
   b. Periodical consideration of trends and progress in the control of accident frequency and severity.
   c. Approval of abnormal expenditures for accident prevention.
   d. Approval of major changes in safety organization and of activities affecting matters of policy.

Operations Safety Committee.—The direct administration of accident prevention in all its phases shall be the responsibility of the operations safety committee, the chairman of which shall report to the executive safety committee.

1. Membership shall consist of the secretary of the executive safety committee, the plant safety inspector, three sales supervisors, and five plant supervisors.
2. Meetings shall be held twice a month, or more frequently as directed by the executive safety committee or as required by special circumstances.
3. A secretary shall be appointed whose duty shall be to prepare the agenda, provide necessary exhibits and factual material for consideration and discussion, and record the minutes.
4. Membership shall be rotated on a quarterly basis.
5. Specific responsibilities and activities of the operations safety committee shall include:

a. The primary specific function of this committee shall be to discuss major accident-producing conditions and circumstances and to take and recommend practical effective corrective action.

Note.—This refers to the pertinent facts of accident occurrence, namely, the outstanding mechanical or physical hazards, also the outstanding personal unsafe acts and the reasons for their occurrence that still remain to be corrected and that in all probability can be expected to have the most effect on accident frequency and severity unless remedial measures are taken.

b. Review of and action on reports of the plant safety inspector.
c. Review of and action on the trailing and observation reports submitted by the sales manager.
d. Review of and action on the reports and recommendations received from the service engineer of the insurance carrier.
e. Review of and action on accident-investigation reports submitted by supervisors.
f. Periodical check of all authorized safety procedures and their proper functioning.
g. Approval of proposed new construction and installation of equipment, changes in procedures and processes, etc., from the safety viewpoint.

Plant Safety Inspector.—Weekly inspections of all structures, yards, machines, tools, and other equipment, processes and procedures, fire-fighting, fire-prevention, and first-aid equipment, shall be made by the plant safety inspector who shall report directly to the chairman of the operations safety committee. The specific activities and responsibilities of the plant safety inspector shall be as follows:

1. At the completion of each weekly inspection he shall prepare a report of his findings, including necessary recommendations for correction of such conditions as still require attention.

2. His report shall contain comments on hazardous conditions found at the time of his inspection, even though they were afterward corrected.

3. His report shall include recommendations and comments not only on mechanical and physical hazards but on unsafe personal performance as well.

Supervisors.—It shall be recognized by all supervisors that they are to be held responsible for the maintenance of safe mechanical and physical work environment and for the safe performance of workers under their supervision. The specific accident-prevention activities and responsibilities of supervisors shall be as follows:

1. Immediate investigation of each personal injury accident, and the completion of the report entitled "Supervisor's Report of Accident Investigation." The original of this report shall be forwarded immediately to the secretary of the operations safety committee.

2. Corrective action in the event of an accident shall be taken immediately by the supervisor when it is within his authorization to do so. When not within his authorization he shall include a recommendation for suitable corrective action in his report of investigation.

3. He shall make daily inspections of the premises and the equipment therein that are under his supervision, with regard to safe working environment and personal unsafe practices, following which he shall take or recommend suitable corrective action, as may be needed.

4. He shall require all employees under his supervision to report injuries, whether minor or major, to first-aid headquarters immediately after their occurrence.

5. He shall instruct each employee as necessary in the safe performance of his work.

6. He shall keep closely in touch with each employee under his supervision, so that he may determine the employee's general physical and attitudinal fitness for carrying on his work safely.

7. Sales supervisors shall be required by the sales manager to make periodical observations of sales-driver performance on the road. After each such observation the form entitled "Observation Report" shall be completed and forwarded to the sales manager. Both unsafe-driving performance as well as noteworthy safe performance shall be recorded on this form, on which shall also be described the corrective action taken or recommended.

8. The garage foreman shall make daily inspection of vehicles, giving special attention to:

a. Tires—as to proper inflation, secure mounting, and wear.

Note.—The use of smooth tires on front wheels is prohibited.

b. Steering gear.
c. Lights.
d. Windshield wipers and horns.
e. Brakes.
f. Windshield vision.
g. Accessories—rear-vision mirrors, fire extinguishers, Interstate Commerce Commission equipment, drivers' report of accident, courtesy cards, etc.

Employees.—Employees shall be expected to abide by all company safe-practice rules and to report all injuries promptly to their foremen and to the first-aid station.

They shall be required to read and sign the company pamphlet entitled "Employee Safety Rules" and to sign and return the safety pledge that is incorporated therein.

FORMS AND PROCEDURES

Note.—In the plan of safety organization from which the foregoing items were taken, sample copies of necessary forms were included, together with directions for their preparation, routing, and final disposition.

Items other than those listed above were also included. These related to the placing of responsibility for accident occurrence; also to contests, bulletins, notices, safety posters, motion pictures, and other incidental matters.

In addition, the plan was accompanied by a personally signed message from the president, a set of commonly violated safe-practice rules, and instructions regarding the emergency application of first aid, including the prone-pressure method of artificial resuscitation.

Major Objective of Safety Committee Meetings.—In the foregoing example it will be noted that item 5*a* states that the primary specific function of the operations safety committee is the discussion of *major accident-producing conditions and circumstances* and practical corrective action.

All the formality, procedure, and records in the world will not make a safety meeting of value, if major *objectives* are not *known* and *well defined* or if *action is not directed to the accomplishment of these objectives.*

It takes time and it costs money to hold a safety committee meeting. Too often the matters discussed are of too trivial nature. Why then are such meetings held?

The answer is obvious. The safety committee meeting is the one place commonly accepted as the safety forum, the place where information can best be spread, opinions stated, facts disclosed, and the commendable and worth-while business of conserving lives and limbs and accident dollars best conceived and directed.

There can be but *one primary objective* of a safety committee meeting. Notwithstanding the fact that many items may be included legitimately on the agenda—accident reports, accident costs and frequencies, machine guarding, safe employee performance, awards and prizes, unsafe acts and mechanical guarding—there is nevertheless *one* and *only one* main objective. It can be stated as follows: A safety committee is held for the purpose of discussing, and taking effective action on, outstanding accident-producing conditions. This statement holds true for large and small organizations, for vehicle, manufacturing, building, or merchandising operations, and for organizations with good and poor experience.

It can be seen from the wording of this objective that a discussion of past accidents only does not fit the description. Nor are bulletins, slogans, records, or inspection reports primary objectives. Such subjects are valuable items in the functioning of a safety committee, *but they are incidental.* Inasmuch as the chief purpose of the safety committee meeting is to attempt the solution of an important problem it may be of interest to list a few typical accident problems as they should be presented for discussion by the chairman of a safety committee:

1. The frequency of rear-end collisions is out of line with other similar locations. These occur because our drivers *follow too closely*, and *fail to signal* when slowing down and stopping.

2. Costly "run-away" vehicle accidents still occur. These are preventable accidents and cannot occur if vehicles are in good condition and if our rules concerning precautions for parking on grades are observed.

3. Slips and falls occur much too often on floors and work spaces that are unnecessarily oily and slippery.

4. In disregard of posted notices, employees persist in oiling and adjusting machinery while it is in motion.

5. Less than 5 per cent of the employees who are exposed to the hazards of chipping and grinding wear safety goggles, notwithstanding that goggles are available and that our rules require their use.

The secretary of a live and effective safety committee meeting will place items such as those listed above on his agenda. He may get them from an analysis made locally, from the insurance service engineer, from the safety committee headquarters, or elsewhere. The point is, he should know what his problems are and should see that they are discussed and acted on at the meeting.

Immediately after the routine business of the meeting is over, the highest executive present should proceed at once to discuss the local accident problem of most interest. With problem 2 above before him he might say:

"In the last 6 months, two trucks have 'run away.' This has happened and will probably happen again unless we do something effective about it. In each case the vehicle was reported in good condition prior to the accident, and the driver swears that it was left properly parked at the curb. It doesn't check. Trucks don't 'run away' by themselves. The accident reports say nothing of children at play who tampered with the brakes. Admitting that each and every accident may not always be preventable, yet this particular kind of an occurrence should seldom, if ever, exist under safe conditions as to vehicle and driver. There is nothing more important for us to do at this meeting than to discuss ways and means of preventing future 'run-away' vehicle accidents."

The meeting could then be thrown open for general discussion. If it showed signs of developing nothing of value, the chairman should submit definite questions for criticism or approval. He might suggest the advisability of carrying and using wheel blocks, of studying the ability of emergency brakes to hold the car on steep grades or rerouting traffic to avoid grades, of blocking the shift lever in reverse, of holding a special meeting of drivers for the specific purpose of talking about "run-aways," or of posting a series of letters or bulletins devoted to "run-aways."

In short, when a specific problem has been uncovered, its solution should receive concentrated attention in every respect.

This is what is meant by the primary objective of a safety committee meeting.

Incidentally, locations with good experience as well as those with poor experience have safety problems and should follow like procedure. In any location there is always some safety activity that is of more importance than something else. Even if it were true that all items had exactly the same degree of interest, it would still be of value to pick one out arbitrarily and feature it.

Even in the perfect location, should there be such a place, where no accident-producing conditions of any kind exist and where the meeting is of value chiefly as an educational medium and in maintaining interest, a problem can be selected from the group of procedure items in the safety program. Right and wrong ways of filling out supervisor's reports of accident investigations, for example, could be featured to advantage. In any event, it remains true that detail and routine of a casual and perfunctory nature is not the objective of an effective safety committee meeting. Good men and valuable producers gather at these meetings. There is plenty of important work to do. It can best be done if there is a clean-cut conception of what a safety committee really is, what it should do, and how it is expected to go about it.

Without fail, at all meetings of safety committees anywhere and anytime, a "*problem*" of a specific nature, clearly stated, sufficiently proved and with tentative solutions ready for discussion, should be ready for presentation.

First Aid and Hospital.—Other than brief comment on first aid and hospital is inconsistent with the expressed nature and scope of this text, inasmuch as the theme is accident prevention rather than injury treatment. The two subjects, however, are closely related, and it is granted that it may often be as advantageous to control the severity of an injury by prompt and proper treatment as to prevent the occurrence of the accident injury originally.

All industrial establishments, even the smallest, where workers may sustain injury, should have at least a common-sense minimum of first-aid equipment, plus provision for medical and hospital service in the event the latter is required.

The minimum in first-aid medical, and hospital facilities therefore is described as follows:

1. A first-aid cabinet that is kept continuously stocked in accordance with local requirements.

Note.—In the event there are no local requirements, the first-aid cabinet should contain the items listed hereunder.

2. A competent first-aid attendant should be available during all working hours. He should be properly instructed by a physician or by some other recognized authority.

3. Hospital facilities and the services of a physician should be available.

First-aid Cabinet.—In every plant and at all times, there should be present at least one first-aid kit. Cases for first-aid kits should preferably be made of either metal or glass, so constructed as to exclude dust and be kept clean. Once a month or more often, the contents of the kit or kits should be checked. After any of the material or contents of the kit are used, they should be immediately replaced.

The contents of each first-aid case should be substantially as follows:

Instruments:

1 pair scissors
3-inch splinter forceps
Tourniquet
Graduated medicine glass

Drugs:

2 ounces or a minimum of 10 ampoules of aromatic spirits of ammonia
Boric acid—liquid, powder, or tablet form, to make 4 per cent solution
2 ounces or a minimum of 10 ampoules of tincture of iodine, half strength
2 collapsible tubes, 3 ounces, of burn dressing or at least six individual tubes
2 ounces castor oil (for eye injuries)

Dressings:

1 dozen sterile gauze bandages, assorted sizes, and 1 dozen assorted compresses in sealed packets
1 five-yard spool of 1-inch adhesive plaster
3 packages, ½ ounce each, of absorbent cotton
Splints of assorted sizes for fractures, or wire splints
Wooden applicators wound with cotton
1 dozen wooden tongue depressors

All bottles or other containers of drugs or other substances should be clearly labeled, and the specific purpose for which the contents are to be used should be marked thereon.

Dispensary.—First-aid equipment alone is not sufficient for the larger industrial concerns even though more than one cabinet is provided. Consideration should be given to dispensaries, plant emergency hospitals, and the full-time services of physicians.

The following is given as representative requirements for a plant dispensary:

A dispensary building or room on the premises, with running hot and cold water, should be set apart from all workrooms and should contain a stretcher and at least the equivalent of a standard first-aid outfit, as previously described.

A graduate nurse who should devote his or her entire time to attendance at the plant dispensary during working hours. This should be interpreted as meaning in the dispensary or in a room adjoining it, and instantly available at all times for the treatment of accident cases. This should not prevent the nurse from assuming auxiliary work during the time he or she is not needed for dispensary service, provided, however, such work is not incompatible with emergency dispensary duties and is not given precedence over the nursing work.

Emergency Hospital.—The emergency hospital should be a building, room, or rooms set apart and on the premises.

A nurse should be provided.

A doctor licensed to practice medicine in the state having jurisdiction should be available to call during all working hours and should make at least semiweekly visits to supervise the medical work of the plant.

If a doctor licensed in the state having jurisdiction is present during all working hours, such arrangement is acceptable in lieu of the requirements of the two paragraphs immediately preceding.

The hospital should contain the following equipment:

Operating table, instruments, and instrument case
Couch and chairs
Table for dressings
Sterilizers for instruments and dressings
Drugs, medicines, splints, dressings, basin, etc. The supply of drugs, dressings, etc., should be in accordance with the needs and personnel of the plant, as specified by the plant physician.
Hot and cold running water
Lighting facilities—complete

Stretchers should be conveniently located throughout the plant.

The following instruments should be considered a minimum requirement in states having no official standard for equipment. (In states having laws bearing on this item, such laws shall apply.)

1 bandage scissors
1 sharp-pointed dressing scissors
1 blunt dressing scissors
1 medium-sized thumb forcep
1 splinter forcep
1 probe, silver
1 groove director
6 small artery clamps
1 hypodermic
1 razor
2 scalpels
1 dozen assorted suturing needles
1 needle holder
1 tourniquet
6 tubes of catgut, plain, No. 1 or 2
6 tubes of catgut, chronic, No. 1 or 2
1 hank of silkworm gut
1 card of black suturing silk
Other instruments as required by the attending physician

Resuscitation.—One or more persons, the number depending on the size of the plant, should be trained in resuscitation. The following[1] rules apply to the prone-pressure method of artificial respiration as approved by the U. S. Public Health Service and other organizations.

When patient has ceased breathing due to electric shock, gas poisoning, or drowning, artificial respiration should be administered.

As soon as possible, feel with your fingers in the patient's mouth and throat and remove any foreign body (tobacco, false teeth, etc.). If the mouth is tight shut, pay no more attention to it until later. Do not stop to loosen the patient's clothing, but immediately begin actual resuscitation. Every moment of delay is serious.

Lay the patient on his belly, one arm extended directly overhead, the other arm bent at elbow and with the face turned outward and resting on hand or forearm, so that the nose and mouth are free for breathing.

[1] "Handbook of Industrial Safety Standards," revised 1938 edition, published by the National Conservation Bureau.

Kneel, straddling the patient's thighs, with your knees placed at such distance from the hipbones as will allow you to assume the position shown.

Place the palms of the hands on the small of the back with fingers resting on the ribs, the little finger just touching the lowest rib, with the thumb and fingers in a natural position and the tips of the fingers just out of sight.

With arms held straight, swing forward slowly so that the weight of your body is gradually brought to bear upon the patient. The shoulder should be directly over the heel of the hand at the end of the forward swing. Do not bend your elbows. This operation should take about two seconds.

Now immediately swing backward so as to completely remove the pressure.

After two seconds, swing forward again. Thus repeat deliberately, twelve to fifteen times a minute, the double movement of compression and release, a complete respiration in four or five seconds.

Continue artificial respiration without interruption until natural breathing is restored, if necessary four hours or longer, or until a physician declares the patient is dead.

As soon as this artificial respiration has been started and while it is being continued, an assistant should loosen any tight clothing about the patient's neck, chest, or waist. Keep the patient warm. Do not give any liquids whatever by mouth until the patient is fully conscious.

To avoid strain on the heart when the patient revives, he should be kept lying down and not allowed to stand or sit up. If the doctor has not arrived by the time the patient has revived, he should be given some stimulant, such as one teaspoon of aromatic spirits of ammonia in a small glass of water, or a drink of hot coffee or tea. The patient should be kept warm.

Resuscitation should be carried on at the nearest possible point to where the patient received his injuries. He should not be moved from this point until he is breathing normally of his own volition and then moved only in a lying position. Should it be necessary, owing to extreme weather conditions, etc., to move the patient before he is breathing normally, resuscitation should be carried on during the time that he is being moved.

A brief return of natural respiration is not a certain indication for stopping the resuscitation. Not infrequently the patient, after a temporary recovery of respiration, stops breathing again. The patient must be watched, and if natural breathing stops, artificial respiration should be resumed at once.

In carrying out resuscitation, it may be necessary to change the operator. This change must be made without losing the rhythm of respiration. By this procedure no confusion results at the time of change of operator, and a regular rhythm is kept up.

Take care of the patient. An unconscious person becomes cold very rapidly, and chilling means a further strain on a vitality already weakened. Experience has shown that the cold, to which the victims of gassing, electric shock, or drowning are often carelessly exposed, is probably the most important cause of pneumonia, and this disease is the most dangerous aftereffect of all these accidents. As far as possible, keep the patient covered while artificial respiration is being given. Use hot pads, hot-water bottles, or hot bricks, but remember that an unconscious man has no way of telling you when he is being burned.

If it should be necessary to move the patient, keep him lying down and do not permit him to exert himself.

Never give an unconscious man anything to drink. It may choke him. Medical science knows no drug that of itself will start the respiration of a patient whose breathing has ceased.

Continue artificial respiration for at least four hours in all cases. Breathing has returned after eight hours in a case of electric shock, but in such instances the patient will give some evidence of recovery that will cause continued effort on the part of his rescuers.

Medical men have sometimes been mistaken in declaring patients dead, and employees of public-utility companies have succeeded with resuscitation after such declaration. Therefore, the ordinary and general tests for death should not be accepted, and any doctor should make several very careful and final examinations and be sure specific and unmistakable evidence is present before pronouncing the patient dead.

CHAPTER XIII

ACCIDENT STATISTICS

The term "accident statistics" correctly implies *mass* data. Such data are only as valuable as the individual single case records on which they are based. In other words, the origin of mass data is the original accident investigation report that has already been described in Chap. IV. Statistics, nevertheless, play an important part in the prevention of accidents chiefly because the facts of no one individual accident or of those relating to small groups of accidents could possibly be representative of a general national or state situation or even of a sizable industrial operation. In addition to the implication of *mass* data, the term "statistics" also indicates exposure with regard to time. It is clear, therefore, that although the individual accident investigation report is the basis of accident statistics, dependence, nevertheless, must be placed upon the latter as a reliable guide drawn from past experience and applicable to the present and to the future.

Of the many illustrations that could be cited indicating the need for statistics as above described, none is better than the situation that exists in a newly begun industrial operation where no accidents or at least few have yet occurred. It would be unwise under such circumstances for the plant to forego accident-prevention work altogether, pending the development of its own accident experience, and such safety activities therefore as are conducted must be predicated on existing data. In other words, reliance must be placed on accident cause data as developed in the experience of comparable industrial operations and as recorded ready for use.

The value of statistics is further indicated by the fact that the experience of any one individual or experience drawn from a limited source is quite likely to be misleading. Individuals have hobbies and pet aversions that often lead them (conscientiously enough, but mistakenly) to emphasize unnecessarily the importance of certain hazards. Better from every point of view would be the knowledge, obtained from accurate country-wide data, that in a given industry most accidents occur when employees engage in certain unsafe practices, such, for example, as oiling machinery while in motion, operating certain machines while guards are disconnected or misadjusted, or exposing themselves to other equally definite hazards, and that they do these things in willful disregard of safe-practice rules or because of some other equally specific personal fault.

The cause of accident prevention suffers today from a dearth of accident statistics that have direct value. It is only fair to say that this is not the fault of statisticians but is due to the lack of available data of the right kind. Perhaps, too, the importance of complete data in the form of accident statistics has not been fully recognized. From the point of view of those charged with the responsibility of preventing accidents, the ideal situation would be one wherein the direct and proximate accident causes, (unsafe practices, reasons for these practices, and the mechanical hazards) and also the frequency, cost, type, extent of disability, nature and severity of injury, and other less important facts with regard to each kind of industrial work, were tabulated and made available for use. The true causes of accidents, however, are not commonly indicated by present-day statistics.

It is well to bear in mind also that, regardless of the lack of data, and whatever the statistical difficulties, the accident-prevention engineer *must* deal with proximate causes of accidents in his work. There is no escape. He has no other recourse. When he recommends that a machine be guarded his defense or reason can only be that he believes its unguarded condition is dangerous and will probably be the *cause of accidents.* Accidents caused by unguarded machines are decreasing in number, however, whereas those resulting from personnel failure are becoming more common. The recommendations for preventive measures must, therefore, be of a different character. If, in accordance with this trend, the safety engineer suggests that employees stand clear of suspended loads, he does so because he believes that failure to correct this specific unsafe practice will *cause* accidents, and it is also implied that he believes the employees have not been instructed or, if instructed, that the instructions have not been enforced. This implication exists because his recommendation is usually left with the executives and supervisors with the understanding that they will issue and enforce the necessary instructions. In fact, whether or not he is provided with statistical cause data, and whether or not he himself has determined causes by individual analysis, the only justification for recommendations or other safety work, on his part, is the belief that they will assist in the elimination of accident causes. It may be difficult, at present, to establish universally a system whereby accident data obtained from employers of labor will be so complete and accurate that statisticians can separate accidents resulting from personnel failure from those caused by improper physical conditions. It may be impracticable at present to assign all accidents on a national basis to the causes discussed in Chap. IV. Be this as it may, the fact must be faced that in carrying on practical safety work "on the job," a cause must be assumed for each accident that is properly analyzed, and that cause should be attacked if there is to be progress in accident prevention.

One indication of progress with regard to statistics, negative at first glance, but of positive value in its indication of a change in trend of thought, is the generally accepted conviction that so-called "accident-cause codes" have not really been *cause* codes at all but have merely indicated accident *types* or the agencies involved in the occurrence of accidents.

Recognition of Weakness in Present Statistics.—Quotation in this connection is made from the U. S. Department of Labor *Bulletin* 276.

No department of statistical inquiry more closely touches the public weal than the study of personal injuries by accident. Statistics of industrial accidents should serve for accident prevention, for the due administration and intelligent revision of workmen's compensation laws, and for the computation of compensation insurance rates. For *accident prevention it is needful to know how and why accidents occur.* For the better administration of workmen's compensation laws it is necessary to have an accurate statistical record of the disposal of compensation cases—not only the comparatively few cases which are formally passed upon by the administrative board but the immensely larger number of claims which are settled between the parties with only a *pro forma* administrative approval. For the intelligent enactment and revision of compensation legislation legislators must know the number and character of accidental injuries, the extent of wage loss, and the cost in per cent of payroll of any proposed scale of benefits. Lastly, for the computation of insurance rates it is necessary to have not only the actual pure premiums by industries but a detailed analysis of the accidents which occasion the pure premiums.

To serve these ends, accident statistics must be analyzed by industry, *by cause of accident*, and by nature and location of injury and extent of disability, and must be so cross analyzed as to show the correlation of each of these sets of facts with every other. Still other analyses are necessary. It is important to know the number, ages, and relationships of dependents in fatal cases and the age and wage groups of the injured in all cases. In certain industries an occupational analysis will be of value. It goes without saying also that the payroll exposure should be obtained by industries and that the wage loss and the amount of compensation and of medical aid should be shown by industry, by cause of accident, and by nature and location of injury and extent of disability. Many other statistical studies will prove necessary for particular purposes. Nevertheless, the classifications by industry, cause, and nature and extent of injury are primary. Faulty analysis in these respects will vitiate the whole statistical output. Vice versa, if these fundamental classifications are sound and adequate, everything else can be added as opportunity and occasion arise.

The most cursory examination will show that the official industrial accident statistics of the United States are lamentably weak in just these vital particulars. No one state has yet published statistics that are at all adequate to its own needs, and no two states have produced results that are in any way comparable. One state department follows the census classification of industries, another uses the schedules of the old liability manual, a third the literal classifications of the compensation insurance manual. The *classification of accident causes* is sometimes so meager as to be of little *value for prevention*, sometimes so prolix and ill digested as to afford no comprehensive view. The classification of injuries ranges from the simple division into fatal and nonfatal to an individual list of permanent disabilities—the mere raw material of statistics. While weightier matters have been thus neglected, much time and labor have been expended upon such unprofitable subjects as race, conjugal condition, day of the month, day of the week, and hour of the day.

National and State Codes.—It is not improbable that the difficulties now confronting statistical accident cause-analysis may shortly be overcome. Progress at least is being made in this direction. Under the auspices of the American Standards Association and the joint sponsorship of the International Association of Industrial Accident Boards and Commissions, the National Safety Council and the National Council on Compensation Insurance, a classification of accident causes has been completed by the committee to which the task was assigned. The substance of the committee's findings and recommendations was adopted and put into effect by the state of Pennsylvania in 1938. It has also been included in the "Manual on Industrial-injury Statistics,[1] published by the Bureau of Labor Statistics, United States Department of Labor, from which manual the following excerpts have been taken.

The comprehensive classification and code for accident cause-analysis given here are based on a revision of the "Proposed American Recommended Practice for Compiling Industrial Injury Causes," more popularly known as the "Heinrich Cause Code."[2] This classification was designed to supersede the provisions relating to causes in *Bulletin* 276, "Standardization of Industrial Accident Statistics," published by the U. S. Bureau of Labor.

The subcommittee recognized the need for accident data of more value for purposes of accident prevention than those now available. It also recognized that an entirely new approach was necessary and that existing codes, generally, were faulty in not bringing out the necessary facts in such a fashion as to be easily handled statistically and in such a form as to be practically useful for accident prevention. The basic philosophy of the proposed code is that accidents occur because of an unsafe act or a condition, or both, which, if eliminated, should prevent a recurrence of such accidents.

To make the unsafe act and unsafe condition intelligible and meaningful, however, they must be related to the framework or setting in which the accident occurred. Knowing that the unsafe act was the removal of a guard is not sufficient. It must be clear that the guard was removed from the gear of a machine, say a lathe, and that as a consequence the worker's hand was caught between the gears. Changing somewhat the order of the items named, we must know: (1) the defective object most closely connected with the accident, which may be a machine, a

[1] Prepared by Max D. Kossoris, U. S. Bureau of Labor Statistics.

[2] 1937 edition, American Standards Association. The version presented here is patterned after a preliminary draft of the subcommittee of the Sectional Committee on Standardization of Methods of Recording and Compiling Accident Statistics, 1939.

tool, a device, a vehicle, an animal, a substance, etc., and which in this code is called the "agency"; (2) the part of the agency; (3) the unsafe mechanical or physical condition; (4) the type of accident, that is, whether a fall, a slip, being struck by an object, an industrial disease, etc.; (5) the unsafe act; and (6) the unsafe personal factor.

This method of analysis breaks an accident into its component parts, which may then be combined in whatever way will best serve the purpose of accident prevention. The application of the classification will be made clearer by tracing a given accident through the various stages of analysis. The accident selected is one occurring on a lathe and resulting in an injury to the worker's hand because it was caught between the unguarded inrunning end gears. The guards were removed by the worker, contrary to instructions, to facilitate cleaning. The coding for this accident is as follows:

1. Agency: Lathe.
2. Part of agency: Gears.
3. Unsafe mechanical or physical condition: Unguarded.
4. Accident type: Caught in, on, or between.
5. Unsafe act: Removing safety devices.
6. Unsafe personal factor: Willful disregard of instructions.

From these coded facts the accident can be reconstructed as follows: A worker was injured because he was caught between the gears of a lathe which was unguarded because he had removed the safety devices (that is, the guard) in willful disregard of instructions.

If this accident were coded in keeping with the prevailing practice, the cause of the accident would be coded as a lathe—with probably no further information. Nothing would be reflected in the coding to show that the lathe was unguarded, that the worker had removed the guard, and that he had done so in violation of instructions. The contrast between the analysis under the proposed code and the bare indication under the prevailing practice that the accident involved a lathe amply illustrates the differences between the two methods of approach. It should be equally clear that the coding method proposed here furnishes important information for the direction of safety efforts, whereas other coding methods most decidedly fail to do so.

All the refinement of coding, however, is useless if the coder does not have the necessary insight into accident hazards to permit a clear recognition of the unsafe practices and unsafe conditions involved in the accidents reported. In the absence of such insight, which can come only from practical experience, the coding is wasted, the resulting statistics most likely will be wrong, and the data submitted to guide factory inspectors and safety engineers may be faulty.

Purpose of Classification.—The purpose of this classification is to provide a statistical method of analysis of accident factors, from which information essential for accident prevention can be compiled.

This classification is predicated on the proved theory that nearly all industrial accidents are preventable. The accident-cause factors are recognized as an unsafe condition, an unsafe act, or a combination of both. The analysis proposed here is aimed at bringing out those unsafe factors that are most closely related to the injury and that lend themselves to correction. The classification is not intended to deal with obscure causative factors or factors too far removed in the accident sequence to be definitely ascertainable.

Definition of Accident.—An accident is an event involving the contact of a person with an object, or a substance, or another person, or the exposure of the person to objects, or conditions, or the movement of a person, which results in a personal injury.

Note.—Certain single occurrences, such as explosions, may result in injuries to a number of persons. This code requires that an accident be coded and tabulated for each injury. The term "accident," as here defined, includes industrial (occupational) diseases.

It is appropriate to state, at this point, that the manual from which these excerpts are taken deals with such accidents as cause personal injury. It is recognized however that many similar accidents fortunately do not result in personal injury and that others may cause property damage only. The foregoing definition would apply equally well to the two last mentioned situations if amended by the substitution of the phrase "which results in personal injury or the probability of such injury or in property damage" for the phrase as actually given in the definition.

The Accident and Its Causal Factors.—The analysis outlined here matches the method followed by a safety engineer when investigating an accident. He begins with the injury and determines that a certain machine, tool, or other object, substance, or exposure was most closely associated with the injury, and that a particular part of the machine or object was closely associated with the injury. His interest centers chiefly about those agencies and agency parts which are unguarded or unsafe. As a next step, he identifies the particular accident type which occurred, this being a fall, struck by, caught in, on, or between, etc. He then seeks for an unsafe act of a person which brought about the accident resulting in the injury and determines also the unsafe personal factor which brought about the unsafe act.

The accident factors, therefore, are:

1. The agency.
2. The agency part.
3. The unsafe mechanical or physical condition.
4. The accident type.
5. The unsafe act.
6. The unsafe personal factor.

The rules for selection pertaining to each of these factors will be found with the appropriate classification for each factor.

Definitions of Accident Factors.

The Agency.—The agency is the object, substance, or exposure which is most closely associated with the injury and which could have been properly guarded or corrected.

The Agency Part.—The agency part is the particular part of the selected agency which, chiefly because it could have been guarded or corrected, is most closely associated with the injury.

The Unsafe Mechanical or Physical Condition.—The unsafe mechanical or physical condition is the condition of the selected agency which could and should have been guarded or corrected.

The Accident Type.—The accident type is the manner of contact of the injured person with an object, substance, or exposure, or the movement of the injured person, which resulted in the injury.

The Unsafe Act.—The unsafe act is that violation of a commonly accepted safe procedure which resulted in the selected accident type.

The Unsafe Personal Factor.—The unsafe personal factor is the mental or bodily characteristic which permitted or occasioned the selected unsafe act.

Examples Illustrating Accident Cause-analysis.

1. A painter fell from a ladder having a split rung. The ladder was used contrary to instructions. The rung broke and the painter fell to the floor, breaking his leg.

The defective agency most closely related to the injury is the ladder. No agency parts are given for ladders in this classification, and therefore none is to be named. The unsafe mechanical or physical condition is the defective condition of the ladder. The accident type which resulted in the injury is a fall to a different level. The unsafe act is using defective equipment. The unsafe personal factor is the willful disregard of instructions. The selected accident factors, therefore, are as follows:

Agency: Ladder.
Agency part: None.
Unsafe mechanical or physical condition: Defective agency.
Accident type: Fall to a different level.

Unsafe act: Using unsafe equipment.
Unsafe personal factor: Willful disregard of instructions.

2. A painter fell as in Example 1, and in falling struck against an inexperienced oiler who was oiling the unguarded gears of a moving lathe. The man falling from the ladder was not injured, but the oiler's fingers were caught between the gears.

There are two defective agencies in this example, the ladder and the unguarded lathe. The rules require that the lathe is to be named because it is most closely associated with the injury in point of time and place. The agency part is the gears. The unsafe mechanical or physical condition is the absence of a guard. The injury resulted because the oiler's fingers were caught between the gears, and the accident type therefore is "caught in, on, or between." The unsafe act resulting in this accident type is oiling equipment in motion. The unsafe personal factor resulting in the unsafe act is the inexperience of the oiler.

The selected accident factors therefore are as follows:

Agency: Lathe.
Agency parts: Gears.
Unsafe mechanical or physical condition: Unguarded.
Accident type: Caught in, on, or between.
Unsafe act: Oiling moving equipment.
Unsafe personal factor: Inexperience.

If the man who fell from the ladder had also been injured, two accidents would have to be tabulated—the accident to the oiler and the accident to the painter.

Agency and Agency Part.

Rules for Selection.—1. Select the unsafe object, substance, or exposure that resulted in the injury and that could have been guarded or corrected.

2. In the absence of an agency as described in rule 1, select as the agency that object, substance, or exposure which was most closely associated with the injury.

Note.—The term "closely associated" requires consideration of both location and time as well as cause. If more than one agency is related to the injury, select the one on, in, or about which the person was injured (closely related by location). If two or more agencies are remotely located from the place of injury, select the one nearest the injury in point of time.

3. A person is to be selected as an agency only when there is no other.

4. No object or substance shall be named as the agency when it is structurally and physically a part of some other object or substance at the time of injury, or when it flies or breaks off the parent object or substance immediately prior to the injury. For example:

a. A flywheel is properly part of an engine. It may be named as the agency itself, however, if it was not an integral part of the engine immediately prior to the injury.

b. A fragment of a burred chisel flies off and causes injury. The chisel is to be named as the agency.

5. The rules for selecting the agency parts are the same as rules 1 and 2 for the selection of agency.

Classification of Agency and Agency Part.—There are 16 major agency groups, each of which is developed in considerable detail. If so desired, classifications or tabulations may be made on the basis of these major groups. These groups are:

Code	Agency Classification by Major Groups
00	Machines
01	Pumps and prime movers
02	Elevators
03	Hoisting apparatus
04	Conveyors
05	Boilers and pressure vessels
06	Vehicles
07	Animals
08	Mechanical power-transmission apparatus
09	Electric apparatus
10	Hand tools
11	Chemicals
12	Highly inflammable and hot substances
13	Dusts
14	Radiations and radiating substances
15	Working surfaces, n.e.c.[1]
19	Agencies, n.e.c.
XX	Unclassified—insufficient data.

[1] N.e.c.—not elsewhere classified.

Each of the above major groups has been developed in further detail but has not been quoted here. Agency parts for these groups have also been selected.

Analysis can be made in great detail if desired, it being one of the advantages of this classification that it makes available when wanted the detailed data along any particular line of investigation.

The Unsafe Mechanical or Physical Conditions.

Rules for Selection.—1. Select the unsafe mechanical or physical condition of the agency or agency part that is chiefly responsible for the injury and that could have been guarded or corrected.

2. Name the unsafe mechanical or physical condition, if one existed, regardless of whether or not an unsafe act was committed.

As in the case of the agency, unsafe mechanical or physical conditions may be classified and coded in general categories or in detail. The general categories are as follows:

Code	Classification by Major Groups
0	Improperly guarded agencies
1	Defects of agencies
2	Hazardous arrangement, procedure, etc., in, on, or around the selected agency
3	Improper illumination
4	Improper ventilation
5	Unsafe dress or apparel
9	Unsafe mechanical or physical condition, n.e.c.
x	Unclassified—insufficient data
y	No defective agency.

The above items can be classified in greater detail if desired.

Accident Type.

Rules for Selection.—Select the accident type that is immediately associated with the selected agency.

Code	Classification of Accident Type
0	Striking against (refers generally to contacts with sharp or rough objects, resulting in cuts, slivers, punctures, etc., due to striking against, kneeling on or slipping on objects)
1	Struck by (falling, flying, sliding or moving objects)
2	Caught in, on, or between
3	Fall on same level
4	Fall to different level
5	Slip (not fall) or overexertion (resulting in strain, hernia, etc.)
6	Contact with temperature extremes (resulting in burning, scalding, freezing, heat exhaustion, sunstroke, frostbite, etc.)
7	Inhalation, absorption, ingestion (asphyxiation, poisoning, drowning, etc., but excluding contact with temperature extremes)
8	Contact with electric current (such as results in electrocution, shock, etc.)
9	Accident type, n.e.c.
x	Unclassified—insufficient data.

The Unsafe Act.

Rules for Selection.—1. Select that violation of a commonly accepted safe procedure which resulted in the selected accident type.

Note.—The unsafe act may have been committed by the person injured, a fellow worker, or some other person.

2. If more than one unsafe act was committed, select the one most closely associated with the selected accident type.

3. Name the unsafe act, if one existed, whether or not an unsafe mechanical or physical condition existed.

As in the case of the unsafe mechanical or physical condition, the classification of unsafe acts may be used in general groups or in detail. The general classification is as follows:

Code	Classification of Major Groups
0	Operating without authority, failure to secure or warn
1	Operating or working at unsafe speed
2	Making safety devices inoperative
3	Using unsafe equipment, hands instead of equipment, or equipment unsafely
4	Unsafe loading, placing, mixing, combining, etc.
5	Taking unsafe position or posture
6	Working on moving or dangerous equipment
7	Distracting, teasing, abusing, startling, etc.
8	Failure to use safe attire or personal protective devices
9	Unsafe acts, n.e.c.
x	Unclassified—insufficient data
y	No unsafe act.

A detailed classification is provided for the above items.

Unsafe Personal Factor.

Rule for Selection.—Select the unsafe personal factor that resulted in the selected unsafe act.

In keeping with the general structure of this classification, the unsafe personal factors may be classified in general groups or in specific detail. The general group classification is as follows:

Code	Classification by Major Groups
0	Improper attitude
1	Lack of knowledge or skill
2	Bodily defects
9	Unsafe personal factors, n.e.c.
x	Unclassified—insufficient data
y	No unsafe personal factor.

The above major groupings are given in detailed form in the code from which this quotation is made.

PRESENT-DAY STATISTICS

With relatively few exceptions, accident-cause data available today are not factual or specific enough to have other than a general value. There are, however, some notable exceptions. The practice in the state of Pennsylvania[1] has already been mentioned, and reference has likewise been made to the "Manual on Industrial-injury Statistics" published by the U. S. Department of Labor. In addition, individual industrial plants have established systems for the investigation of accidents and for the recording of pertinent accident facts with methods and results closely approaching those discussed in this text.

In one nation-wide concern, for example, the facts of each accident that occurs throughout the country, after careful investigation, are tabulated in such a way as to show not only the kind of accident, the extent of injury, the degree of responsibility and other corollary and incidental facts, but likewise the machine, tool, object, or other agency and the specific unsafe personal performance as well. However, accident investigation and the tabulation of accident facts have not yet progressed much beyond the stage that has been described in the foregoing quotation from U. S. Department of Labor *Bulletin* 276.

Notwithstanding the lack of progress, there is much of value even in the existing incomplete accident-cause data. State accident-cause codes assign accidents to general cause classifications such as:

1. Machinery.
2. Vehicles.
3. Explosions, by electricity, fires, and hot substances.
4. Poisonous and corrosive substances and occupational diseases.
5. Falls of persons.
6. Stepping on or striking against objects.
7. Falling objects (not being handled by injured).
8. Handling of objects.
9. Hand tools.
10. Animals.
11. Miscellaneous.

[1] Excerpts from the 1939 Statistical Supplement of Industrial Injuries in Pennsylvania are given in the Appendix.

These general classifications are sometimes subdivided. For example, the general cause classification 1, machinery, is subdivided into the three groups

a. Prime movers.
b. Power-transmission apparatus.
c. Power-working machinery.

These subdivisions are further detailed as, for example, under group *c* (power-working machinery) practically all commonly used machines in the various industries are separately listed.

It is evident that the originators of codes of the kind described above when selecting the term "cause" referred to in the title, did not intend that it should refer to any of the several phases of man failure but rather to the agency or the vehicle or other object that was involved.

From the point of view from which such codes were designed, they serve an excellent and useful purpose. By means of their application, accidents may be assigned to specific machines or to hand tools or to the handling of objects, and a point of attack is thus localized for the accident-prevention engineer to study.

Before he can proceed effectively with the application of a practicable remedy, however, he must determine from analysis *why* accidents occur on machines or while handling tools or carrying on a particular operation. Specifically, he must determine whether the machine is suitably guarded; whether any other physical or mechanical cause exists such as poor light, congestion, or defective equipment; or whether, under normal physical operating conditions, man failure, as identified by one or more of the personal causes of accidents (unsafe acts) discussed in Chap. IV of this book, is at fault.

Safety Council Data.—Valuable accident statistics are provided by the National Safety Council. In a pamphlet entitled "Accident Facts, 1940 Edition," data appear relating to the accident-frequency and severity records of individual industrial operations.

Existing Plant-accident Records.—Statistics based on state-wide or country-wide data have less significance for the employer or for the accident-prevention engineer who is responsible for the control of accident frequency in an individual manufacturing plant than like statistics of lesser scope relating to the particular plant accident history in which he is directly concerned.

Specific data of immediate value to him must be obtained from the accident records of the plant or from an outside service agency such as the engineering and inspection division of his insurance carrier. Records should in any event invariably be maintained at the plant.

There are many kinds of plant-accident records in use at the present time. Only those that bear most directly upon accident prevention require discussion here. In the smaller industrial establishments it is not practicable to maintain elaborate recording systems, but in principle the situation is alike in both large and small organizations and need differ only in detail and volume.

Accident records serve a twofold purpose: (1) They provide a picture, in permanent form, of data derived from the past that may have specific value in existing or in future safety work; and (2) they make available a mass of data covering past periods, from which conclusions can be drawn that could not be obtained from a more limited study of currently occurring cases.

From the general information tabulated in accordance with common existing practice, summaries may be drawn off at regular intervals, indicating:

a. Accident frequency.
b. Location by plant, department, machine, or operation, requiring first attention because of frequency or severity of injuries.
c. Type of accident—falls, struck by, etc.
d. Type of injury—burns, fractures, bruises, etc.
e. Predominating general causes of accidents.
f. Progress or trend in control of frequency and severity rates.

For the average plant, a record of lost-time injuries only is insufficient. Injuries of this type occur with relative infrequency and provide so limited an exposure that it is impossible to draw accurate conclusions from them, with regard to cause and remedy. Luck and other factors, difficult to control, play too great a part in the severity of an injury, once the accident has caused it. *All* injuries, therefore, including *all minor first-aid cases* as well as major or lost-time injuries, should be taken into account and be used as the basis for statistical systems of recording accidents.

For recommended plant practice in record keeping the reader is referred to Chap. IV.

Necessity for Improvement in Accident Statistics.—Study of statistical data shows that there is opportunity for progress in accident statistical work. The data now available are of real value. It is valuable to know that one branch of industry produces a higher frequency of injuries than another; that "handling of objects" and "falls of persons" predominate as types of accidents; that these accidents produce varying degrees of injury and loss of time; and that men are injured by poisonous or corrosive substances, or at the point-of-operation of machinery, etc. But the man who does the work of accident prevention must know the real causes of these accidents before he can accomplish the desired results.

Example Showing Value of Minor-accident Statistics.—Many hundreds of examples could be cited to prove the truth of the assertion that the greater volume of minor accidents provides a more valuable clue to accident cause and remedy than do the lost-time accidents. One example will suffice, for present purposes.

For two years the employees in the cutting and finishing rooms of a boot-and-shoe manufacturing plant in Massachusetts had suffered a high frequency of injuries. Those that resulted in lost time were due to unsafe and negligent practices in pulling and lifting heavy boxes of soles and heels.

Because of persistent safety work, the accidents from this kind of work decreased in the third year but were replaced by a still greater frequency of even more serious injuries resulting from wholly different conditions. This was a discouraging development, but it directed attention to the necessity for proper analysis of all accidents.

At this time an attempt was made to prepare a cause-analysis from statistical data gathered from an over-all injury study. This resulted in a quite natural but (to the management) astounding discovery that the most prolific cause of accidents had been for several years, and still was, the practice of piling bundles of shoe taps, wires, and leather scrap in the aisle spaces of the finishing and stitching rooms, contrary to oral and printed instructions. Directly or indirectly, this practice had given rise to more than

40 per cent of the accidents in each of the two preceding years. Yet, because it had not caused *lost-time* accidents, preventive activity for two years had been focused on lifting and pulling boxes in an improper manner, to the exclusion of practically all other direct safety work.

It is clear that minor accidents should be recorded as faithfully and accurately as those that are more serious.

This discussion has purposely been confined to data that relate to accident *prevention*. Of course, accident data for other purposes are necessarily desirable. Certain additional information, for example, is required by the labor departments of individual states, for the purpose of identification and to determine eligibility for compensation, and under certain circumstances the statements of witnesses are required.

For accident prevention itself, however, especial emphasis is placed on the value of assigning true causes. The value of statistics lies in the conclusions that may be drawn from them and upon which corrective action may be based. Statistics provide a valuable clue to the causes of future accidents. The term "clue" is used deliberately because it is unwise to apply a remedy for the occurrence of accidents based wholly on the lessons of the past. But with the conclusions drawn from statistics as a guide, a study of present conditions may be more profitably made and a final decision as to the method of eliminating existing known accident causes more readily be reached.

The complete application of statistics in the cause-analysis phase of accident prevention is a task for the future. It should eventually become a practical accomplishment. National statistics may never show just *why* and *how* all the various types of accident occur, but it is reasonable to hope that the existing interest in the subject of accident *causes* may lead closer to information from which more effective remedies may be selected. Meanwhile, there is no escape from the fact that the individual accident-prevention engineer must himself, with or without statistical data, determine these causes as best he may when attempting to solve the problems that confront him.

CHAPTER XIV

EDUCATION OF EMPLOYEES

All accident-prevention work, whether or not it be educationally intended, is nevertheless educational in its effect upon the individual employee whom it necessarily involves. It is the employee who suffers injury, and it is the employee who must be made to carry on his work safely, in order that our industries may be reasonably free from accidents. That this is true is clearly indicated by evidence that intelligent and careful men may avoid injury on dangerous work and that careless men may be injured under the safest possible conditions. Education is an important factor in accident prevention, whether employers demand as their right that employees conduct their work safely or merely teach safety to the best of their ability and depend on the employee for personal initiative. The influence of the supervisor or foreman should not be overlooked. Whatever the form that safety education takes, it should be kept in mind that it is the foreman who is in the best position to convey its message to the individual worker and to interpret it for the worker in "shop" language. It can be said with justification that if the foreman is thoroughly "sold" on safety, he in turn will "sell" the employees whose work he directs.

In practice education is not broadly defined. Ordinarily it refers to meetings and talks, personal contacts with authorities or teachers, the use of bulletins and posters and other reading matter, stereopticon slides and motion pictures, first-aid instruction, and any oral or written instruction in avoiding hazards and cultivating safe methods of doing work.

Limitations of Education.—Education, in the ordinary sense of the word, has its limitations. Employees may be talked to or talked at, they may read pages of printed matter and view pictures by hundreds, and yet fail to apply the message to themselves. This is particularly true when educational efforts are general in nature—when they preach safety, its value, its necessity, and its other virtues, and fail to specify what and where and how. Obviously, the limitations of mass education as a safety effort are due chiefly to the necessity for such generalization.

This necessity has existed in the past partly by reason of the fact that real accident causes were not determined. When educational efforts are applied in mass or even to small groups of employees, it is difficult to be sufficiently specific with regard to the safety problems of each individual, to teach him what things to avoid, how to avoid them, and how to conduct his particular work safely. Educators are obliged therefore to deal largely with matters of common interest to all, and the individual, even though converted to safety and enthusiastic in his determination to avoid accidents, is often left to his own initiative and devices when he returns to work. Specific safety educational work therefore is largely a task for supervisors and foremen, who, by virtue of their authority and close daily contact with employees, are in a position to convert safety generalities to the everyday safe-practice procedures that apply to individual tasks, machines, tools, and processes.

Education and Supervision.—These limitations do not exist, however, when education is combined with other safety work that results in the determination of specific accident causes, types, and locale, and when proper supervisory methods in accident prevention are followed. In fact, in such coordination of safety procedures lies the key to the heart of the situation, as far as education is concerned. Employees should be taught not only that safety is worth while, not only that it is their duty to themselves, their families, the community, and their employers to avoid injury, but *they should also be told what specific dangers in their own line of work should be guarded against and what specific things they themselves may do to avoid injury.* The most effective way to teach them these things is to utilize ordinary supervisory methods *just as they are already being used to teach the control of volume and quality of product.* Instruction or education along such lines must be predicated upon predetermination by analysis of accident causes and types. It must be apparent, therefore, that this description of safety education does not really refer to education in its commonly understood sense but to the methods whereby management and its supervisory staff train and instruct employees and encourage and enforce the observance of safe-practice rules.

Education undoubtedly is a vitally important part of safety work. The intent here is to point out how best it may be applied.

Education per se accomplishes its objective by inference and by induction. The aim is to teach the individual employee to be safety-conscious, in the hope that he himself will thus be able to sense the existence of specific unsafe practices and conditions and will avoid them of his own volition. If time and the necessity for speedy results were not factors, there could be no more pleasant or fruitful method of controlling accident frequency. In times of stress and emergency, however, one looks for stronger and more direct means, and, as the situation becomes acute, one leans logically toward methods that savor of the militaristic.

This is a natural tendency, and it is to be deplored when carried to unreasonable lengths that create resentment and destroy morale. Men go farther when properly led than when driven, although they may not get under way so quickly or proceed so rapidly at the start.

The necessity for safety educational work in the industries is justified primarily because employees are not informed or because they do not know how to apply their knowledge. Thus, again with reference only to industry, safety education is the process of imparting knowledge of safe and unsafe mechanical conditions and of safe and unsafe personal practice.

In its broader sense, outside of the field of industrial safety and especially with regard to classroom work, the process of education implies discipline of the mind and body, and it deals therefore with approaches and backgrounds and requires a continuity and regularity and a step-by-step planning that is often quite impractical in the case of the average plant or other industrial operation.

The industrial and traffic safety courses that are conducted in high schools and colleges by local safety councils and by insurance companies are most commendable and valuable. Consistent, however, with the stated scope and objectives of this book, the treatment of such phases of education is omitted in favor of more direct safety educational work that is best described as imparting or acquiring knowledge of pertinent accident facts and the exercise of normal supervisory procedures in the encouragement and enforcement of safe practices and conditions.

In any event, a happy combination of education with other more forceful business methods is the better choice as far as the work of industry is concerned.

Employers Have a Right to Demand That Wage-earning Employees Follow Rules as to Safe Practices.—Employers can, with fairness to all, hold employees accountable for violations of safety rules. With this as a primary principle, general educational safety work may be added, with the result that the ideal situation is approached. It may be well to repeat, here, the thought that forms the theme of this book: "Dependence must be placed upon the three principles of accident prevention:

1. Creating and maintaining interest.
2. Fact finding.
3. Corrective action.

in formulating safety educational programs, preparing safety rules, posters and literature, and in carrying on successfully any other phase of industrial accident prevention."

The following cases describe commonly used safety educational methods:

(Case 1 is advisedly so listed for the reason that the foreman, who is admittedly the key man in industrial safety work, receives a better education in safety when he himself is obliged to make a complete and factual investigation of the accidents that occur to his men than in any other way.)

Case 1

This example, taken from the records of a textile plant, is typical of many industrial concerns where the education of employees in safety was successfully accomplished primarily by proper use of a supervisor's report of accident investigation.

Mass meetings of employees had proved ineffective, largely because no single specific subject could be selected that applied to all who attended. Topics for discussion, therefore, were necessarily quite general. They dealt with carelessness and thoughtlessness, loss of time and wages, the effects of accidents in terms of physical injury, family security, and similar matters.

Smaller group meetings were not much better. Posters, notices, films, and playlets accomplished somewhat more favorable results, but these too lacked "punch" because they did not get down to the real hazards of the individual worker.

Emphasis placed on specific safe-practice rules aroused more interest than the methods that were first adopted and provided the clue that finally influenced management to direct educational work to the *foremen* and through them to the employees.

It was found that the education of individual workers progressed more quickly because these safe-practice rules applied directly to their work. In addition, the foremen found that they could explain and enforce specific safe-practice rules that applied to their own departments far more readily than the generalities that had been discussed previously.

With the foregoing circumstances in mind a supervisor's report of accident investigation was developed and put into use. One of the leading questions on this form required the foreman to state "what safe-practice rule was violated," another asked "what mechanical hazard existed," and a third question related to corrective action taken or proposed.

Thus the foremen, because of the procedure required in making use of the form, were obliged first to find the essential facts of accident occurrence and second to make use of them in correcting the unsafe acts of employees and mechanical hazards.

Some of their first attempts to find and name specific unsafe acts were little short of ludicrous. They learned rapidly, however. Furthermore, the use of the form provided an opportunity for the service engineer of the insurance carrier, the plant safety engineer, and management to explain and teach the elements of accident prevention.

The new procedure was found to be highly educational to the foremen and also to the rest of the employees. It directed attention not only to tangible conditions and circumstances but to those which actually existed and which were most in need of correction. It forced concentration on live issues. It required thought and action as well.

No other single step in present-day safety work is of as great educational value as the establishing of procedure that requires the key man of industry—the foreman—to find essential accident facts and to assume the responsibility for enforcing safe practice on the part of his men—both of these procedures being called for when a supervisor's report of accident investigation is approved and used.

Case 2

A Texas oil-refining plant made good use of the so-called "conference" type of safety education.

In addition to the regular functioning of the executive and supervisory safety committees, provision was made for periodical meetings of foremen and key workers in each department. In accordance with a carefully planned program, subjects for discussion were selected in advance of each such meeting, and plans were made for the leadership of discussion and for encouraging participation by the individual members.

Three general topics were selected, namely:

The principles of industrial-accident prevention.
The major causes of departmental accidents.
Corrective action.

Prior to the initiation of the conference meetings, a comprehensive accident pamphlet was prepared. This included a statement covering objectives, nature, and scope of the text and separate exhibits defining an accident and its several identifying and cause factors, practical methods of accident investigation, the responsibilities and opportunities of foremen in accident prevention, corrective action, and typical unsafe acts and mechanical hazards.

The first meetings were devoted to the principles of prevention work. The effort primarily was to obtain uniformity of thought, expression, and understanding as to terms and definitions, objectives and methods.

Subsequent meetings dealt with existing accident causes and corrective action.

Individual participation was strongly featured. Members of the committees were asked to act as chairmen and discussion leaders. Set speeches and the usual type of safety-meeting activity were studiously avoided. Instead, the discussions were of the "round-table" variety where each member was encouraged to take a personal and active part. Arrangements were made for individual members at each meeting to bring up specific subjects for discussion, to ask and answer pertinent questions, and in general to live up to the purpose of the plan as indicated by the expression "conference type meetings."

Case 3

Excellent results in safety education were obtained by a railroad company by featuring safe-practice rules. Rules were printed and issued in pamphlet form. They were clearly worded and specifically designated a great number of the more prevalent violations of safe-practice rules. Literally hundreds of practices were listed in these pamphlets, either as definitely forbidden things or as equally definite orders for safe conduct. Among the forbidden practices the following are typical:

1. Going between or in front of moving locomotives or cars to couple or uncouple them or to connect or disconnect hose.
2. Using feet or hands to adjust draw bar, knuckle, or lockpin while cars or locomotives are in motion or are about to come together.
3. Tightening lubricator glass or water-gauge-glass packing nuts while under pressure.
4. Loading coal on tender while a passenger train is passing on adjacent track.
5. Standing or sitting on side of roof of boxcar or side of hopper or gondola car or standing on top of car, near end, except when operating hand brakes.
6. Walking or being on the railroad, except when required in performance of duty.
7. Wearing ear coverings that interfere with the hearing, while on or about tracks.
8. Using defective transfer plates, gangplanks, or skids.
9. Standing close to pole or rope when poling or roping cars.
10. Leaving crane, derrick, or hoist with load suspended.

In addition to these and many other prohibitions, specific rules for safe practices, such as those given below, were included:

1. Use lever to uncouple cars. If lever is inoperative have proper understanding and full protection before lifting pin by other means.

2. Place coal boards and tools in a position where they will not project over sides of or fall from tenders.
3. Test brakes on cars that are to be controlled by hand brakes before the cars are cut off.
4. Look in both directions for trains, locomotives, or cars on adjacent tracks.
5. Watch to avoid injury from sudden starting, stopping, lurch, or jerk of locomotive, car, or train.
6. Keep a safe distance from passing trains to avoid injury from falling objects or projections on equipment
7. Keep aisleways and walkways free of freight, baggage, mail, express, tools, trucks, transfer plates, gangplanks, skids, or other material.
8. Arrange for protection before going under locomotives or cars to make inspection or repairs.
9. Pull hand trucks, when practicable, instead of pushing them. Pushing a truck loaded in such a way that it obstructs view is prohibited.
10. Wear prescribed goggles when performing work listed below, except where other guards are provided that afford full protection to the eyes:

a. Acetylene welding and cutting.
b. Applying or removing chemical paint remover.
c. Boring, drilling, or reaming overhead.

. . . . .

t. All other industrial operations hazardous to the eyes (to be determined by foreman in charge).

These rules are especially valuable and to the point in this case because they were selected as a result of accident cause-analysis. They represent the conditions that were chiefly responsible for accidents.

In the explanatory matter distributed with these safety rules are found the following significant statements:

Since the vast majority of injuries are due to causes over which the injured persons have control, it follows that if the rules are obeyed, injuries due to the causes covered will be prevented. To this end:

Officers and supervisory forces will regularly make observations and checks and take such action as may be necessary to ensure compliance with the rules.

In brief, the rules, if properly impressed upon employees, should act as a constant reminder of the things they should or should not do to protect themselves from injury. This imposes a responsibility upon officers and supervisory forces to keep the observance of the rules uppermost in the minds of employees.

Arrangements were also made for the rules to be read to the employees by executive and supervisory representatives of the company.

This educational work is only a small part of the excellent safety program carried on by the railroad company. It is a splendid example of the effective use of safety rules when instructing employees as to safe and unsafe practices.

CASE 4

In addition to the adoption of more effective supervisory methods in the enforcement of rules for wearing goggles, the management of a foundry coincidentally inaugurated an educational program of considerable merit, which consisted of two parts. First, a safety playlet was produced. The hero of the story, after a harrowing experience resulting from disregard of rules, was finally convinced that wearing goggles is not only practical and advisable but is actually necessary. The men selected to play the several parts became converts to the idea, and their vivid portrayal of the sketch at departmental meetings had a salutary effect on other employees. The play proved to be of such interest that it was produced, by request, at a number of industrial safety gatherings outside the plant itself. The player personnel was changed at frequent intervals, so that some of the men who objected most strenuously to the wearing of goggles could have an opportunity to take part.

The second part of the program was novel. Most persons are influenced for good or evil by the actions of those with whom they are in close contact, and the beneficial effect of "setting a good example" is commonly recognized. Employees are known to imitate those whom they respect or like or whom they consider leaders, and advantage was taken of this common trait in the effort to bring about the most general use of goggles. Certain loyal key men were selected, who were convinced that goggles could and should be worn, and were instructed to advocate the use of eye protectors by argument and by example but, of course, without the knowledge of the other employees that a prearranged plan was being followed.

After this plan had been put into effect, a group of men in the grinding department, one of whom was an advocate of wearing eye protection, was observed to break up shortly before the noon luncheon period was over, and the following conversation was overheard:

"Come on this way, Jim, you're headed wrong. What the ———?"

"I'll be along in a jiffy, got to go to the tool room first."

"What for?"

"My goggles are cracked. I can't work with them and I won't work without any at all, so I'm going to get another pair."

This workman was liked and respected by his associates, and as a direct result of his example the department in which he worked was the first to reach the 100 per cent mark in the use of eye protection.

All executives and foremen voluntarily adopted the practice of carrying goggles in their pockets and of wearing them when inspecting work where eye hazards existed and even when passing near the grinding, chipping, snagging, and sandblasting operations.

Case 5

By a process of eliminating probable causes of accidents in a machine-tool manufacturing plant, it was discovered that something must be wrong with the processes or with the method of handling work. Accidents did not occur as a result of poor light or ventilation or because of unguarded physical hazards. The employees were experienced, intelligent, and reasonably careful and attentive; safety orders were issued and were enforced by the foremen, and discipline was satisfactory. Nevertheless, a high frequency and severity of injuries prevailed as a result of circumstances of which the following is an example:

Castings for machine-tool bases were made hollow in order to serve as containers for water or oil, and it was necessary to test the castings for tightness. It has been standard procedure for several years to fill these castings with water and, after the leakage test had been made, to empty out the water by tipping them over. The castings were heavy and the tipping-over operation, even though the employees violated no specific safe-practice rules, caused many injuries.

The executives, having been convinced by cause-analysis that this procedure was improper and that other operations were unsafe, believed that by means of safety educational work they would accomplish two desirable results: (1) an even better attitude toward personal safety; and (2) the development of ideas that would lead to the substitution of safer procedure for the unsafe practices in existence. The educational program was therefore planned with a view to accomplishing both objectives.

Safety suggestion boxes were placed about the plant, safe procedure was emphasized at safety-committee meetings, and employees were urged to offer suggestions. A standing offer of a monthly cash prize for the employee submitting the best safe-procedure idea was extended at all safety organization meetings. The attention of the entire personnel, by these and other means, was thus directed to the major cause of accidents. The employees started to think constructively. *Self-education* was in process, and many valuable suggestions were received. Some of them referred directly to the practice of tipping over castings when draining off test water.

The recommended procedure was to provide a tapped and plugged drain hole at the bottom of each casting and to drain off the water by unscrewing the plug. This idea was immediately accepted. It eliminated the tipping-over operation and the hazards that attended it. The new design also proved to be a convenience to the purchasers of the equipment.

Other suggestions were accepted for rerouting material, relocating machinery, and using of air hoists instead of chain falls.

This case well portrays the advantages of *planned* education directed toward the finding and elimination of specific causes of accidents, as against general education that is not directed toward the correction of predetermined unsafe practices and conditions. It also shows that employees, when properly led and encouraged, may educate themselves with benefit to the organization by which they are employed.

Case 6

This is an example of general and specific education, well combined, in a leather tannery. Analysis had localized accidents by type and cause, and it was discovered that what is loosely called "carelessness" was a principal factor.

Careful planning led the executives to the selection of the following education methods:

1. More executive contact with supervisors and workmen at safety meetings.
2. A semiannual dinner.
3. Diplomatic and limited use of the powerful weapon—ridicule.
4. Use of praise.
5. Pointing out specific careless practices and featuring careful methods at meetings, in personal contact, in bulletins, instructions, and posted notices.

There was nothing novel in the thought of having more executive contact, except that it was utilized wholly to impress employees with the real interest of the plant management in accident prevention and, more important still, was used to feature the fact that the executives *were well aware of the specific slipshod methods of doing work*, believed they could be improved, and expected improvement.

The semiannual dinner likewise was of the usual kind, except that here again it was so planned as to concentrate the attention of all, by the remarks made, upon the real issue of unnecessarily careless practices. The relations between the company and its insurance carrier also were emphasized, and it was made clear to the employees that in the final analysis the employer paid the full cost of every accident that occurred, plus hidden costs that probably were four times as much.

In step 3 (use of ridicule) there is an element of the novel, also of danger. In this case, however, the method was cautiously and diplomatically applied and was most effective in its results. Bulletins of a semicartoon variety, depicting bungling practices similar to those that resulted in injuries at the plant, were prepared. These were posted on the safety bulletin boards in departments where such injuries were prevalent, and in the space at the bottom of each bulletin was inserted a signed statement by the superintendent, similar to the following:

> Five more fumbling accidents occurred in this department last month. How long does it take to learn to be careful?

In the discussions at safety meetings and elsewhere in general contact, such accidents were repeatedly referred to as bungling and fumbling types, and the entire educational effort for a while was planned to ridicule slipshod methods of handling material and of doing other work so that the interest of the employees was aroused; they talked among themselves and to the victims of careless practice, until a natural and favorable reaction was set up. Workmen began to take pride in their ability to conduct themselves safely.

This reaction was fostered by well-directed praise. Notices were posted occasionally, referring to careful work. The following is typical:

> NOTICE
>
> The management commends Walter Bryant for his skill. He has carried on millwright and machine maintenance and repair work of a difficult nature so well that his accident record for the year just completed is absolutely clear.

The danger of using educational safety methods that employ ridicule as a means of getting results lies in the possibility of arousing resentment and of creating discord and lowered morale. Observe in this case, however, that ridicule was not directed specifically at any one individual, whereas in the case of praise the employee was actually named. In many ways that need not be described here, extreme diplomacy was exercised. This recital should not necessarily be accepted as advocacy of such methods. The case is given merely to illustrate specific educational effort.

Planned Education.—In this chapter a sharp distinction has been made between the ordinary safety educational methods too generally employed in our industrial activities today and planned education that is intended to teach recognition and avoidance of known accident causes. Both are good, but planned education is so far superior in all respects that there is no good reason for failure to adopt it, especially when the method of determining real accident causes may be applied so readily.

Precedent in other lines of safety work supports the thought of planned educational efforts in the industries. For example, grade-school curricula now include safety on the streets and highways, and children are taught to look both ways before crossing streets and to cross at the proper time and in the right place on all occasions. They are repeatedly warned of the danger of playing in the streets, running out in front of moving vehicles, and "hooking" rides, and are cautioned to avoid traffic hazards of many other kinds. Safety classes are formed, and safety drills are conducted.

Specific hazards are featured, not as a result of blind selection but because they are *known causes* of accidents.

No-accident Contests.—There is considerable educational value in no-accident contests and drives, no-accident weeks or months, and other high-pressure safety campaigns. Although these activities, by their nature, provide small opportunity for specialization in individual accident causes and types, they often produce highly satisfactory results.

Contests create rivalry; they necessitate comparison of one record with another or with a goal or target record; they create enthusiasm and maintain interest in the objective. Ordinarily, however, these special contests are based primarily on "lost-time" accidents only, and this involves a certain disadvantage that would be avoided if the reduction in the number of all injuries, including those that do not result in lost time, were to be used as a measure of success.

The occurrence of lost-time accidents or serious injuries, in itself, does not always provide an accurate measure of the conditions out of which they arise. One department of a plant as compared with another, or one plant as contrasted with another similar plant, may have done better safety work and may have safer working conditions, and yet the lost-time accident record may be less favorable because a single workman suffered a serious infection as the result of a relatively minor laceration and lost several weeks' time. Something of this kind often occurs in practice.

Two plants in New England, of approximately the same size and performing the same kind of work with similar equipment and mechanical operating conditions, competed for honors in a no-lost-time accident contest.

In one plant a great many accidents occurred, including several falls from working platforms. Several of these falls resulted only in sprains and contusions, although any one of them might well have caused a fracture.

In the other plant the frequency of accidents was nearly 75 per cent lower. Here, too, a few falls occurred, and one of them (under conditions almost identical with those that prevailed in the first plant) resulted in a compound fracture of an employee's arm. The lost time following this accident produced a poor record in what was admitted to be the safer plant.

Luck has no place in accident prevention, but it undoubtedly plays a part in the severity of injuries resulting from accidents and should therefore be weighed and discounted in making use of the contest idea.

The details of contest planning and execution are many and diverse. The individuals or units chosen to participate in the contest are notified, time limitations are set, the measure of progress is designated, the objectives are indicated, and the contest begins.

Sometimes nothing further is done except to prosecute the actual accident-prevention work as energetically and successfully as possible and to take appropriate action when the contest is ended. In other cases the procedure is more elaborate. Clocks, thermometers, charts, and records in other forms are used to indicate progress; factors or weights are applied to individual departments or operations that are more hazardous than others; and flags, emblems, bonuses, and other prizes and awards are offered to create and maintain the enthusiasm of the participants.

At best, the no-accident contest is a temporary or intermittent expedient, because it cannot be applied continuously and still retain its individuality and force. It has its place, however, as a worth-while incidental to more direct and more effective accident-prevention work.

General Safety Education.—In harmony with the author's purpose, less emphasis has been placed upon general safety education than upon other educational efforts of a more definite character. This, however, should by no means be understood as reflecting on the ultimate value of general education as one of the means of securing safer industrial conditions. By such means the foundation of future safety is strengthened, interest and enthusiasm are created, and the mind of the individual is made receptive to suggestions of a more specific nature.

Safety Organizations as an Educational Medium.—Regularly established safety organizations are of considerable value, even when members have no knowledge of major accident causes and definite remedies. The discussion of individual accidents at the meetings of these organizations stimulates interest, physical hazards are brought to light, and at regular intervals the attention of the committee members is concentrated on accident prevention. These things cannot fail to be beneficial even though they may not always lead to immediate action of a concrete nature.

Members of safety-organization committees often serve only for limited periods. In other words, the personnel is changed from time to time, thus exposing many individuals in a given organization to worth-while contact with safety work. Plant inspections are made, reports are made, opportunity for contact and for discussion is provided, new ideas are broached, and, in general, membership on safety committees creates a better understanding of the relation of accident prevention to production, of the attitude and interests of the employers, and, of course, of the fundamentals and details of safety work itself. By all means, the use of safety organizations should continue to receive encouragement. They should be employed, however, on a *planned* basis with knowledge of major accident causes and remedies, if possible. But, plan or no plan, they accomplish much that is to be desired.

Outside Agencies.—Under the heading "General Safety Education" may be included the excellent work done by insurance companies, local and national safety councils, schools, chambers of commerce, magazines and newspapers, national and state labor departments and industrial commissions, engineering, technical, and statistical organizations, and many other groups and individuals. The means and methods used include lectures and addresses, radio broadcasts, preparation and circulation of printed matter, inauguration of safety campaigns, lantern slides, motion and "talking" pictures, engineering research, preparation of safety codes, and legislation and enforcement procedure.

These activities, to be sure, do not provide an answer for the industrial executive who wants to know how to prevent accidents in his particular plant, and of necessity they are general in nature.

They reach the public at large, however, including industrial workers who must eventually benefit to such an extent as to justify the time, effort, and expenditure involved.

Miscellaneous Educational Activities.—In the foregoing examples some special phase of safety educational work has been featured. It is seldom, however, that success is achieved when only one of the many forms of safety education is utilized. Best results, rather, are achieved when, in addition to emphasizing one particular step, the program is made to include helpful corollary activities. Some of the more commonly used educational procedures are listed hereunder:

1. Placing responsibility on foremen for the investigation of accidents and for correcting unsafe practices and mechanical hazards.
2. Safety meetings, especially conference type meetings.
3. Publicity—safety bulletins, posters, notices, special letters, payroll envelope inserts, slides and films, house organs, etc.
4. Safety plays.
5. Instruction in first aid and resuscitation.
6. Employee rule books.
7. Hiring and training programs.
8. Use of loyal employees in "setting a good example."
9. Safety messages on work orders, on correspondence, etc.
10. Contests.
11. Job safety analysis.
12. Featuring specific safe-practice rules.
13. Attendance at safety conferences.
14. Preparation of safety codes.

CHAPTER XV

SUMMARY

The story of scientific accident prevention has been told. In this final chapter are recapitulated the major points which it has been the purpose of the author to present.

When a situation exists that creates loss of life, injury, and suffering; when it costs a king's ransom annually; when its cure has been demonstrated to be practical; and when all are agreed that something can and should be done about it, it is time to stop talking, roll up the sleeves, and *go to work*.

Such a stage has been reached in industrial-accident occurrence. Thousands of deaths and hundreds of thousands of painful injuries occur annually, and these accidents cost billions of dollars. Both humanitarian motives and economic necessity are therefore urgent incentives to action.

That effective action is within the realm of practical possibility is indicated by the knowledge that more than 90 per cent of all accidents are of a preventable type and that the majority of these accidents are due, wholly or in part, to man failure in common forms that are susceptible of control through the exercise of proper supervision.

Accident-prevention engineers must know *why* and *how* accidents occur; they must know the *causes* of accidents and direct their attack to the removal of those causes, instead of selecting a remedy blindly or arbitrarily. Real causes, sufficiently complete and representative to serve as a practical guide, have been listed. When as a result of cause-analysis the specific unsafe conditions and practices that are chiefly responsible for accident occurrence are known, and when the reason *why* they exist is understood, the obvious remedy may be applied with entire confidence that the procedure is correct. There are no mysteries and few highly technical conditions to contend with. Only ordinary ability and common sense are required either to analyze accidents or to select and apply preventive methods.

Natural laws are favorable in this work, in that the first departure from safe conduct does not necessarily result in an injury but must, in the average case, be repeated several hundred times before the inevitable penalty is exacted. In the recognition of this fact, and in the knowledge that these hundreds of unsafe acts and mechanical hazards that precede an injury are all visible, lies the opportunity to attack successfully the problem of accident occurrence.

It is a most happy circumstance also that elaborate, expensive, or experimental methods are not required and that only good management and supervision, of the kind now commonly applied to the control of quality and volume of production, are necessary.

A more favorable set of circumstances could hardly be imagined. Industry is interested and eager to progress. The tools and the ability are available, and results are being demanded. Apply the principles as set forth here, and a most spectacular achievement with tremendous humanitarian and economic benefits is within reach.

Many important phases of industrial-accident prevention have necessarily been lightly sketched or omitted altogether in order that no detail, however interesting or important, should detract from emphasis on the principles. Heating, ventilation, and sanitation are each worthy of elaboration. The medical aspects of accident prevention could well be considered. Getting the injured worker back on the job, physical examinations, first-aid and hospital treatment at the plant, cooperation with outside physicians and surgeons, physiotherapy, resuscitation, physical fitness of employees and selection and training for specific work, dental and ocular examinations, rehabilitation, and medical control of infections are all closely associated with the problem of accident prevention.

Legislation, safety codes, and cooperation with the labor departments and public and industrial-health bodies of municipalities, states, and federal government play important roles in accident prevention, but they have not been given space here because of the desire to stress simple fundamentals.

Little has been said of wages and hours or of recreation, employee home life, sports, benefit associations, plant comfort and convenience facilities such as lunchrooms, showers, and lockers, or many other things that relate to morale and its obvious effect upon the occurrence of accidents.

Vibration and noise as factors in safety are interesting and pertinent subjects for discussion. The author has for several years made frequent use of the subway turnstiles in a large city on the Atlantic seaboard and had become so accustomed to the tremendous din set up by the clicking of the many rotating barriers as the subway patrons went in and out that he received a welcome surprise one morning when overnight the turnstiles had been converted to the seminoiseless type. It is difficult to portray the vast beneficial change that occurs when excessive noise is abated. It may never be possible to obtain comparative accident data showing the effect of noise reduction on the frequency of injuries, but it is entirely reasonable to believe that it is substantial. Safe walkway surfaces or safe wearing apparel might well be elaborated upon, with much justification, in the knowledge that these are inherently matters that affect safety.

Building construction and fire prevention are likewise closely related to this subject. Under certain circumstances any one of these phases of accident prevention may be a major issue of extreme importance, yet elaboration is withheld here in order that space may be given to accident-prevention fundamentals.

Nor does space permit treating of hazards that are peculiar to specific industrial activities such, for example, as the handling of explosives, caustics, corrosives, acids, and other chemicals, and of heavy machinery and materials, or the hazards in certain industries from heat or cold, dust, occupational disease, and dangerous machines and operations of various kinds.

But the basic principles of scientific accident prevention have been completely set forth and substantially illustrated. By the application of these principles attention is automatically directed to the particular phase of an individual problem that requires attention, whether it be machine guarding, supervision, medical treatment, illumination, or any one or more of the many things that have not been discussed in detail. Best of all, by the use of true principles, the path to the point chiefly at fault is direct, and unnecessary and wasteful experimentation with nonessentials is obviated. Even in rare cases where control of medical expense or improvement in medical care or other matters that are only indirectly related to the actual prevention of accidents are troublesome, procedure such as has been advocated is beneficial.

The burden and the responsibility for initiative in accident prevention rest largely upon the employer and his executive and supervisory staff, although the advantages are shared by all, with the employee, perhaps, enjoying the greatest direct benefit.

It is chiefly to the employer, therefore, that this work is directed. It is by him that our industries are conducted and that the workman is brought into contact with industrial equipment and processes that may result in loss of life or bodily injury. The plant owner confers a boon upon humanity by giving profitable employment to the workers, but he cannot escape the obvious responsibility that goes with this employment of his fellow men —that of maintaining reasonably safe operating conditions and, further, of promulgating and enforcing rules for the safe conduct of the work necessary to his business.

Action is the key. If there is the will to achieve, if true accident causes are known and remedies are effectively applied, there can be no question of results. From the point of view of the industrial executive, no innovations are required. He may apply to accident prevention the very same methods that are successful in controlling the quality and volume of product. The task is simple but not easy. It requires intelligence, understanding, and application. The ability and the power to prevent accidents lie at hand. The machinery is established, the tools are available —there remains nothing but hard work based upon thorough understanding of principles.

APPENDIX I

CHRONOLOGY OF INDUSTRIAL ACCIDENT PREVENTION[1]

Author's Note: Included in this chronology are all the dates that are considered important in the industrial safety movement. There may well be others that have been omitted.

AERONAUTIC SAFETY

1905 International Aeronautic Federation founded for the purpose of regulating aeronautic sports.

1918 Air Mail Service started.

1919 International Air Convention held at Paris. Among other things, the convention provided for the creation of the International Commission for Air Navigation under the direction of the League of Nations.

1921 President Harding, in his inaugural address, urged the enactment of an aerial code.

1921 Air Law Conference held by Secretary of Commerce, Herbert Hoover.

1921 Aeronautical Chamber of Commerce of America founded.

1922 International Commission for Air Navigation met in Paris.

1926 Air Commerce Act passed.

1928 First National Aeronautical Safety Conference held.

1938 Civil Aeronautics Act passed, creating the Civil Aeronautics authority and providing for federal control of all aviation.

1939 The commercial air lines of the United States completed their first full year without a single fatality and with no serious accidents. For this achievement they were awarded special recognition for safe transportation.

INDUSTRIAL SAFETY

1833 England.—Government factory inspections established.

1844 England.—Law enacted to provide fencing for mill gears and shafts. Lord Ashley's "Great Factory Act."

1867 Massachusetts.—Instituted factory inspection.

1869 Germany.—Acts passed providing that all employers furnish necessary appliances to safeguard health and life of employees.

1869 Massachusetts.—Established the first state bureau of labor statistics in order to determine the kinds and causes of accidents.

[1] Contributed by E. R. Granniss, National Conservation Bureau.

1874 France.—Law enacted providing for special inspection service of workshops.

1877 Massachusetts.—Law passed compelling guarding of dangerous moving machinery.

1885 Alabama.—Passed employers' liability law.

1885 Germany.—Bismarck prepared and had enacted the first compulsory compensation act for workers. This act covered only sickness. (Germany was the first country to abandon the employers' liability system for that of workmen's compensation.)

1887 Massachusetts.—Passed an employers' liability law.

1892 Safety Department of the Joliet Works of the Illinois Steel Company formed. This has been called "the birthplace of the American industrial-accident prevention movement." The first safety order was the inspection of all engine flywheels.

1897 England and Austria-Hungary.—Passed workmen's compensation laws.

1898 France and Italy.—Passed workmen's compensation laws.

1903 Russia.—Passed a workmen's compensation law.

1909 First National Conference on Industrial Diseases held.

1911 New Jersey.—First state workmen's compensation law passed.

1911 California.—Passed the first American law for the compulsory reporting of occupational diseases.

1912 Congress.—Passed a law taxing out of existence the occupational disease "phossy jaw."

1921 International Labour Organization at Geneva set up a safety service.

1922 Greenburg and Smith introduced the impinger, a dust-sampling device, which resulted in the impinger method becoming the standard for the U. S. Bureau of Mines and the Public Health Service.

1926 "Benzol Poisoning Study."—In 1922 a paper on benzol poisoning was read at the National Safety Congress. It created so much interest that a committee was formed by the National Safety Council to study and report on the subject. The final report of this committee was published by the National Bureau of Casualty & Surety Underwriters in May, 1926, for the Chemical and Rubber Sections of the National Safety Council. In the report, the problem is stated, the research work described and suggestions made for the use of substitutes. The safe use of benzol and the proper treatment of workers is also described.

1926 "Four-to-one" accident cost ratio established, by the Travelers Insurance Company. The study of several thousand accidents indicated that incidental costs of accidents such as loss of time and spoilage of material are four times the compensation and medical costs.

1927 A study of the relation between safety and production was made by the American Engineering Council in 1926 and 1927. The council was invited to make this study by the National Bureau of Casualty

& Surety Underwriters which also volunteered to finance the project. The final report, which was submitted to the publishers in 1937, was the first authentic treatise on the subject of safety as related to production.

1929 "The Foundation of a Major Injury" published by The Travelers Insurance Company. This research indicated that in a unit group of 330 similar accidents, all from the same proximate cause, 1 resulted in a major injury, 29 in minor injuries and 300 in no injuries whatsoever.

1933 The U. S. Public Health Service in cooperation with coal-mine operators, the United Mine Workers of America, and the Department of Labor and Industry of Pennsylvania undertook a survey of pulmonary disease in the anthracite mines. They determined that disabling pulmonary fibrosis among coal miners was due to silica and not to coal dust.

1936 The Air Hygiene Foundation was created to conduct scientific studies and investigations for finding ways and means of preventing occupational diseases and for promotion of industrial health.

1941 Industrial hygiene departments set up in 33 states.

1941 At the beginning of 1941 all states except one, Mississippi, had compensation laws in effect. Arkansas became the forty-seventh state.

1941 The Accident Cause Code was completed by the American Standards Association. This code introduces an era of accident-cause standardization in the United States, overcoming a weakness in industrial-accident prevention that has long existed.

INSURANCE

Babylonian Code of Hammurabi IP 206 "If a man strike another he shall be responsible for the physician."

Biblical times "And if men strive together, and one smite another with a stone, or with his fist, and he die not, but keepeth his bed:
"If he rise again, and walk abroad upon his staff, then shall he that smote him be quit: only he shall pay for the loss of his time and shall cause him to be thoroughly healed." (Exod. 21: 18–19.)

1864 First accident insurance policy in North America issued by The Travelers Insurance Company. Incidentally, this was the first policy issued by that company and also the first casualty policy written in North America.

1886 First printed liability policy issued by the Employers' Liability Company to the Geuder and Paeschke Manufacturing Company of Milwaukee.

1898 First automobile public liability and property damage insurance policy issued by The Travelers Insurance Company.

PERIODICALS

1900 *Safety Engineering* founded by Franklin Webster and published by Alfred M. Best Company.

1911 *American Journal of Public Health* published by American Public Health Association.

1912 *Travelers Standard* published by the Travelers Insurance Company.

1913 *Safety* published by the American Museum of Safety until 1926, thereafter a joint publication with the Greater New York Safety Council.

1919 *National Safety News* published by the National Safety Council.

1919 *Industrial Hygiene and Toxicology* published by the Williams & Wilkins Company.

1924 *Safety Education* published by the National Safety Council.

1925 *Industrial Safety Survey* published by the International Labour Office.

1932 *Industrial Medicine* published by Industrial Medicine Publishing Company.

1935 *Industrial Supervisor* published by the National Safety Council.

1936 *Industrial Standardization* published by American Standards Association.

RAILWAY SAFETY

1833 George Stephenson suggested use of a steam whistle on locomotives.

1851 Charles Minot, general superintendent of the Erie Railroad, issued the first telegraphic train order.

1870 Westinghouse airbrake adopted by the railroads.

1872 First electric automatic signal system installed on the Pennsylvania Railroad.

1882 Manually controlled block system of signalling used by the New York Central Railroad.

1883 One standard time adopted. (Forty-eight different standards had previously been used.)

1885 First test of the automatic coupler made by the Master Car Builders' Association.

1887 Interstate Commerce Commission created by the Interstate Commerce Act. Among its powers are regulation of common carriers engaged in foreign and interstate commerce; investigation of all railroad accidents; and prescription of safety appliances and equipment for railroads and motor carriers.

1893 Federal Safety Appliance Act required use of standard safety equipment on railroad trains.

1903 First steel passenger car constructed.

1908 Transportation of dangerous explosives act passed.

1919 National Railroad Accident Prevention Drive inaugurated.

1922 Careful Crossing Campaign inaugurated.

1934 Federal funds appropriated to make railroad crossings safer.

1939 Railroads of United States and Canada transported some 500,000,000 pounds of high explosives without an accident or an injury.

SAFETY ORGANIZATIONS

1866 *National Board of Fire Underwriters*

OBJECTIVE: This organization is maintained by stock fire insurance companies. Having found that its duties of rate making for the entire country in earlier years proved too ponderous, its principal functions today are in other directions particularly toward uniformity and better practices in the fire insurance business.

1885 *American Society of Mechanical Engineers*

OBJECTIVE: To establish standards for mechanical industries and encourage the development of mechanical engineering science.

1893 *Underwriters' Laboratories*

BACKGROUND

1893 This organization was founded by William H. Merrill in Chicago. He was employed as an electrician by the Chicago Underwriters' Association to solve some problems in connection with the automatic fire alarm service in Chicago, and to inspect the electrical installations at the World's Fair.

1901 Merrill with two helpers set up a small office and by November, 1901, the organization had expanded to such an extent that it was reorganized as Underwriters' Laboratories, Inc.

OBJECTIVE: Testing of equipment and appliances for conformity with high standards of safety.

1896 *National Fire Protection Association*

BACKGROUND: Includes any organization interested in the protection of life or property against loss by fire. It was incorporated in 1930.

OBJECTIVE: To promote the science and improve the methods of fire prevention and circulate information on this subject.

1901 *National Bureau of Standards*

OBJECTIVE: To develop standards for building materials, manufactured products, foods, and drugs. Also to conduct tests to assure purity, safety, and uniformity of products.

1910 *Bureau of Mines*

BACKGROUND

1910 Created in the Department of Interior.

1925 Transferred to the Department of Commerce.

1934 Returned to the Department of Interior.

OBJECTIVE: To investigate the causes of mine accidents, study health hazards, and seek means of correction.

1911 *American Museum of Safety*

BACKGROUND

1908 A voluntary organization was founded under the name of the American Museum of Safety and Sanitation.

1911 Incorporated by special charter from the New York State Legislature. It has three departments: accident prevention; industrial hygiene; and social hygiene. Its activity has been restricted for several years.

OBJECTIVE: To study and promote means and methods of safety and sanitation and the application of remedies.

1912 *Children's Bureau*

1912 Created by Act of Congress.

OBJECTIVE: Investigation and compilation of reports on all matters pertaining to child life including information on dangerous occupations, accidents, and employment.

1912 *Division of Industrial Hygiene of the U. S. Public Health Service*

OBJECTIVE: To study hazards in various industries.

1912 *National Safety Council*

BACKGROUND

1906 United States Steel Corporation set up a safety committee to inspect its works and suggest means of accident prevention.

1907 Association of Iron and Steel Electrical Engineers organized.

1908 Safety committee of the association appointed.

1912 First cooperative safety congress called to meet at Milwaukee, Wis., from Sept. 30 to Oct. 5, 1921. The program was developed by the safety committee of the Association of Iron and Steel Electrical Engineers, and the meeting was attended by representatives of industry, government, insurance, and others.

1912 Committee appointed "to organize and create a permanent body devoted to the promotion of safety to human life in the industries of the United States." This committee organized the National Council for Industrial Safety.

1913 First meeting and organization of the National Council for Industrial Safety.

1914 National Council for Industrial Safety's field of activities broadened, and its name changed to National Safety Council.

1917 This year marked the beginning of the growth of the local safety councils of the National Safety Council.

OBJECTIVE: Collection, development, and dissemination of safety materials of all natures.

1913 *Bureau of Labor Statistics*

1913 Created in the Department of Labor

OBJECTIVE: To acquire and diffuse information that is useful in labor administration.

1914 *Industrial Hygiene section of the American Public Health Association*

1914 *International Association of Industrial Accident Boards and Commissions*

BACKGROUND

1914 In April, representatives of Indiana, Iowa, Massachusetts, Michigan, Ohio, Washington, and Wisconsin met in Lansing, Mich., and formed the National Association of Industrial Accident Boards and Commissions. Later it became the International Association.

OBJECTIVE: Reduction of accident frequency; standardization of means of return to work of injured workmen; standardization of methods of compiling accident and insurance costs; tabulations and methods of administering compensation laws.

1915 *American Society of Safety Engineers*

BACKGROUND

1909 Safety organization known as United Association of Casualty Liability Insurance Inspectors founded in New York City.

1914 Scope of this society enlarged to include noninsurance men in its membership and widen range of activities.

1915 Name, American Society of Safety Engineers incorporated under the laws of New York State.

1919 Meeting to consider possible duplication of work with Engineering Section—National Safety Council.

1924 Name changed to American Society of Safety Engineers—Engineering Section National Safety Council. This society, while retaining its identity, became an organic part of the National Safety Council.

OBJECTIVE: Promotion of arts and sciences connected with safety engineering.

1918 *Saranac Laboratory for the Study of Tuberculosis*

BACKGROUND: Began conducting animal experiments to determine the effects of the inhalation of mineral dusts on the lungs in relation to the development of tuberculosis and other pneumoconioses.

OBJECTIVE: Study of pneumoconioses.

1928 *American Standards Association*

BACKGROUND

1913 U. S. Bureau of Standards started formulation of a National Electrical Safety Code.

1914 American Society of Mechanical Engineers drew up a boiler code that was national in scope.

1918 American Engineering Standards Committee formed from five national engineering societies.

1919 U. S. Bureau of Standards called a meeting of government and state officials, accident-prevention engineers, and insurance men at Washington on Jan. 15 to consider placing the formulation of standards under the auspices of the American Engineering Standards Committee. American Engineering Standards Committee amended its constitution and appointed a committee known as the National Safety Code Committee.

1928 American Engineering Standards Committee reorganized to change it from a committee status to a full-fledged association that was named the American Standards Association. At the time of the reorganization 193 standards had been approved, and 160 others were in the making.

1941 The American Standards Association lists 451 standards that it has approved. Of these 41 are in the field of industrial-accident prevention. One hundred and eighty-nine standardization projects are under way.

OBJECTIVE: The development of standard codes and specifications.

1934 *Division of Labor Standards*

Created by the Department of Labor

OBJECTIVE: To develop desirable labor standards in industrial practice, labor law administration, and labor legislation; and to make specific recommendations concerning methods and measures designed to improve the working conditions and the economic position of wage earners.

1937 *National Conservation Bureau*

BACKGROUND

1896 This bureau had its beginning in the Liability Conference of 1896. From this conference grew the National Workmen's Compensation Service Bureau, which later became the Conservation Department of the National Bureau of Casualty and Surety Underwriters.

1937 The work of the conservation department of the National Bureau of Casualty and Surety Underwriters was reorganized, and the National Conservation Bureau, accident-prevention division of the Association of Casualty and Surety Executives, was created.

OBJECTIVE: Development of material for accident and industrial-disease prevention in industry and cooperation with educational and other groups in the promotion of safety education.

1938 *Center for Safety Education*

BACKGROUND: Established at New York University, under the sponsorship of the National Conservation Bureau.

OBJECTIVE: Safety-education courses including a research seminar; study of materials, methods, and administration of safety courses in elementary and secondary schools; safety procedures in vocational and physical education classes; home safety and first aid.

1939 *American Industrial Hygiene Association*

BACKGROUND: Industrial hygienists in the United States desired an organization for the furtherance of their science.

OBJECTIVE: Advancement and application of industrial hygiene and sanitation through the interchange and dissemination of technical knowledge—the furthering of study and control of industrial health hazards through determination and elimination of excessive exposures.

APPENDIX II

THE BACKGROUND OF INDUSTRIAL SAFETY[1]

Since before the dawn of recorded history man has been distinguished by his industry. The homes of the cliff dwellers, the pyramids, ancient Chinese tapestries, and similar antiquities attest man's industry thousands of years ago. Because his desire for self-preservation and his fear of injury were no less strong then than they are now, accident prevention was undoubtedly practiced to some extent even in the earliest civilizations.

Such efforts were probably almost entirely personal and defensive. Industrial safety, until relatively recent times, was largely a matter of individual effort rather than any sort of organized procedure. The real need for organized safety did not originate until the advent of what is termed "the machine age," and the safety movement, as we have it, is strictly a modern innovation.

From the social standpoint, Britain is most noted for having given the world the art of self-government. However, England was also the cradle of mechanized industry. Prior to 1500, the country was almost wholly agricultural, an aggregation of small, self-sustaining settlements called "manors." Lords and nobles and knights in armor were in the heyday of their glory. This was the period of English history "when knighthood was in flower."

From 1500 to the latter part of the eighteenth century, the British steadily progressed in craftsmanship. Workers in wood, metal, and particularly in textiles attained a high pinnacle of skill.

Then came steam power. James Watt is often said to have invented the steam engine. Actually, he transformed a lumbering monstrosity into a working device that could be depended upon to provide power. His first successful prime mover was in actual operation as early as 1776, turning up 14 strokes a minute as the American colonies won their independence. Significant also was the invention of the cotton gin by Eli Whitney in 1793.

The early years of the nineteenth century saw the mechanization of industry rapidly gain momentum. Simultaneously with the increasing use of steam power, the handicrafts gradually declined. This didn't come about without a struggle, however, for as the textile factory system developed, there were many riots between the hand spinners and factory operators. Machines were even destroyed by hand workers, many of whom did all in their power to hinder plant operation. But merchandise was less costly to

[1] Contributed by E. R. Granniss, National Conservation Bureau.

produce by machines, and eventually the hand worker gave up the losing struggle and took his place at the spinning machine and the power loom.

The birth of industrial power and of industrial safety were not simultaneous. The introduction of English workers to mechanized industry was accompanied by working and living conditions so bad as to defy adequate description. Debasement and social degradation came quickly in industrial centers. The population of Manchester grew to 200,000, though the city contained neither park nor playground. There was no system of water distribution, and workers were compelled after their day's work to go great distances for water and to wait in line with buckets. There were no schools, and living quarters were inadequate. Idiocy and bodily deformities were common. The death rate tripled.

Early Conditions.—These conditions were social. Although they were bad, plant conditions were worse. Factories were little more than shacks. Light, ventilation, and sanitation in those low-ceilinged, narrow-aisled structures were almost nonexistent. Rest rooms were unthought of. Two-thirds of the workers were women and children whose workday was from 12 to 14 hours. Machine guards were unknown. Occupational deaths and maimings were frequent.

Some governmental factory inspections were made in England as early as 1833, but it was not until nearly 1850 that actual improvements began to be made as a result of their recommendations. These efforts were the first attempts by government to improve industrial safety. As time went on, legislation shortened working hours, established a minimum working age for children, and made some improvement in sanitary and safety conditions such as providing for the fencing of mill gears and shafts. These beginnings of improved industrial conditions were a far cry from organized accident prevention as it is recognized today.

Although fatal and disabling accidents were common during early industrial days in England—as they have been in every country during similar periods—damages were seldom paid by plant operators. Lawmakers were slow to legislate for the greatest common good, for the doctrines of "negligence of the fellow servant" and "contributory negligence" were strongly entrenched throughout the world. It was not so long ago that American employers felt they were discharging their obligations to their employees when they gave a job as a sweeper or watchman to a man who had lost an eye, or paid the funeral expenses of a worker who was killed at his machine. Under the existing laws they were usually not even compelled to do this.

The pioneer industrialists should not be judged too harshly for their attitude toward employee accidents. Many benefits, such as improved transportation, better lighting, heating, and plumbing were being realized through the tremendous industrial advancement in the United States, and it was a firmly rooted belief, among employees as well as management, that a certain amount of human suffering and loss of life was necessary if this advancement was to continue. Accidents were accepted as an inherent part of industry. Employers were still unaware of the economic losses that accompany accidents.

And employees too, though they frequently resented the working conditions offered them, were not, in many instances, particularly interested in safety. Notable progress began to be made in plant safety only after plant management began to insist on safe working practices.

Lowell, Mass., was one of the first industrial cities in the United States, manufacturing cotton cloth as early as 1822. The workers were mostly women and children from the surrounding farms, many ranging from six to ten years old, who worked from five in the morning until seven at night. How many girls' fingers and hands were lost in unguarded machinery no one will ever know. It was not long, however, before the increasing number of cotton mills in Massachusetts began to exceed the supply of farmers' daughters. Fortunately for the employers, a potato famine in Ireland greatly increased migration from that country, and many of the Irish settled in and around Boston. Labor again became plentiful for the mills, but with the influx of immigrant help the number of accidents soared. One result was the passage by the Massachusetts Legislature in 1867 of a law requiring the appointment of factory inspectors. Two years later the first Bureau of Labor Statistics in the United States was established. Coincidentally, in Germany acts were passed providing that all employers provide necessary appliances to safeguard the life and health of employees. At last, industry was learning that conservation of the human element was important. A few years later, Massachusetts, having discovered that long hours of activity produce fatigue and that fatigue causes accidents, passed the first enforceable law for a 10-hour maximum working day for women. In 1874 France passed a law providing special inspection service for workshops and in 1877 Massachusetts compelled the guarding of dangerous moving machinery.

Mining Conditions.—The coal mines were, too frequently, subterranean death traps. Danger below ground probably exceeded that above, and the frequent news of men trapped beneath the earth made grim headlines.

One February, in Bradewood, Ill., snow covering the prairies melted, forming a great lake. One hundred feet below, miners were digging coal. Suddenly, the mine roof collapsed, and water poured into the mine. It took three hours for the lake to drain dry. Then rescue crews were sent down. They found 69 dead.

Gas was even more feared by miners than water and crumbling earth. Fire damp is one of the most dangerous gases known to industry. It explodes with the force of dynamite. Black damp is just as deadly but not so noisy. The first warning the miner gets is a headache, and then his lamp refuses to burn. Sometimes, however, these warnings are too slow, and then the men die, quietly, falling off to sleep. White damp is probably the most lethal gas encountered in mining. It usually originates in the powder used for blasting, and it gives no warning. One good whiff of white damp, and a miner drops dead in his tracks.

Although gas hazards were due mainly to poor ventilation, many of the mines in early days had but one shaft to the surface. One morning in September, 1869, in an Abondale, Pa., mine, the wooden beams and planking lining the shaft were set afire by sparks from the hoist-engine boiler. Flames quickly made the shaft a roaring inferno which no man could approach. For hours water was pumped into the shaft, and along toward evening rescue parties were able to descend. They discovered 179 bodies.

Catastrophes of this nature aroused tremendous public indignation. One result was the formation of a group known as the Molly Maguires, who raised havoc in the anthracite fields, being charged with the deaths of a large number of mine bosses. Although it is doubtful if the Mollys had much effect on improving hazardous conditions, they kept the subject of safety alive and demonstrated how a poor accident experience could be made an excuse for mob violence.

White Phosphorus.—White phosphorus matches were first manufactured in this country about 1830. Hundreds of women and children employed in this industry died from what was known as "phossy jaw," a disease caused by the phosphorus mixture used in the heads of "lucifer" matches. This disease attacks the body, when fumes released while molding phosphorus paste becomes mixed with saliva in the mouth, causing the teeth to decay. As the teeth decay and have to be extracted, ports of entry are provided to the jaw bones, which in turn are affected. Persons with "phossy jaw" have large running sores and sometimes lose both jaw bones before death.

Although workers suffered greatly from "phossy jaw" in this and other countries, it was not until 1906 that an international convention sought to prohibit the manufacture and sale of matches made with white phosphorus. In 1912 a treaty to this effect was signed by many countries, and the United States Congress placed a prohibitory tax on such matches, forbidding their importation. An interesting coincidence is that about the time the tax went into effect, a new method of making matches was discovered that eliminated the use of white phosphorus and provided better matches. Nevertheless, for 82 years "phossy jaw" had been a hazard in the manufacture of matches.

River Boats.—The old river steamboat captain was in many ways the counterpart of the modern automobile driver, and many mishaps originated in the personality of the skipper. The early "river hogs" certainly could not be called "sissies"; far be it from them to give way a few feet to avoid a collision! Nor were they too careful about the condition of their operating equipment, and boilers blew up with seemingly greater regularity than tires blow out today. For a number of years, the number of steamboats blown up, burned, or sunk by collision, averaged more than one hundred a year. Naturally, that sort of a record helped to drive passenger traffic to the railroads.

Railroads.—Previous to 1850, railway travel was relatively safe. Speed seldom exceeded 18 miles an hour. Light at night was produced by a pile of blazing pine knots on a flat car, pushed in front of a locomotive. Wet and icy rails were dangerous, too, even at 18 miles an hour, as were the swarms of grasshoppers on the tracks. One year in Pennsylvania, grasshoppers were so thick that they interfered with the running of trains, and men with brooms were employed to precede the trains and sweep the tracks clean. It was about this time that someone thought of using an abrasive to counteract the slipperiness, and the sandbox came into use. The idea worked so well that since that time no locomotive has been built without a sandbox.

Signal systems were an early innovation. Before the days of timetables, the station agent climbed up a watchtower when he thought the train was about due and watched with a spyglass aimed down the track until he could see smoke from the engine. Then, climbing down, he rang a bell and shouted that the train was approaching. The steam whistle, forerunner of the automobile horn, was another innovation. Before whistles came into use, when the engineer wanted to get the conductor's attention, he hoisted a small flag on a pole mounted on the engine, which the conductor could see if and when he stuck his head out of a window.

Early iron rails gave considerable trouble. Frequently, rails would tear loose from the ties and wind around axles, or crash up through the car floors. Sledge hammers used for pounding down loose rails were standard equipment on trains for a number of years.

Legislation.—Legislative action attacking definite physical and mechanical accident causes such as the hazards of specific machine parts and unsafe building or operating conditions has had comparatively little effect because of the unpopularity of such laws and the difficulty of enforcement. However, laws that penalize employers by increasing the costs to them of accidents have had far-reaching effects in causing them to seek out accident-producing conditions and correct them.

The first attempt to modify the common law of employers' liability by statutory enactment was made in England in 1880 when the Employers' Liability Act, permitting personal representatives of a deceased employee to recover damages for death caused by negligence, was passed by Parliament. This act modified but did not eliminate the fellow-servant defense. In America the first statute defining employers' liability was passed by Alabama in 1885. Massachusetts followed in 1887. Both of these acts were modeled after the English statute and were the first indication to the American employer that he was legally responsible for safeguarding his employees against accidents. Despite this early legislation, few employers took much initiative in safety.

Insurance.—Fortunately, a new force was affecting the accident situation. Insurance coverage was playing an important part in the organization of accident prevention. Following the passage of the first employers' liability laws, insurance afforded employers opportunity to purchase protection against unexpected loss resulting from injuries to employees. In turn, insurance companies found it necessary to employ inspectors to visit their new policyholders, primarily to classify risks according to the hazards they entailed so that proper rates might be assigned. As the inspectors, or insurance engineers, became more competent in judging risks, their accumulating experience made them valuable in an advisory capacity concerning the reduction of accident hazards. Thus, through engineering services inaugurated by insurance carriers, employers gradually became aware of safety engineering methods and their potentialities for reducing industrial operating costs. For a long time the main burden of accident-prevention work was shouldered by insurance company engineering and inspection departments which, while protecting their own interests, were also rendering industry an extremely valuable service.

In the earlier days accident prevention had no place in the daily routine of plant work. A few farsighted executives did appoint factory inspectors, but usually such appointees were men apart from the working organization, who confined their activity largely to the correction of unsafe physical conditions. Accident prevention, where it existed, was seldom an inherent part of the production schedule. There were of course notable exceptions to this. In 1892, the safety department of the Joliet Works of the Illinois Steel Co. was formed and did remarkable work. Some writers have referred to this organization as the "birthplace of the American industrial-accident-prevention movement." Here, the first safety order was for the inspection of all engine flywheels. It should be stated in passing that the National Fire Protection Association was organized in 1895 and since that time has done a remarkable work in the saving of life and property from fire. Fire prevention, however, is an independent science and will not be discussed.

Workmen's Compensation Laws.—In 1911 another stride forward in organized accident prevention in the United States was made. Again, it followed needed legislative action. This was workmen's compensation. In Germany, in 1885, Bismarck had prepared and had enacted the first compulsory compensation act for workers. It covered only sickness. Germany was the first country to abandon employers' liability in favor of workmen's compensation.

In 1897 a workmen's compensation act was passed in Great Britain. This was the first law of its kind in an English-speaking country, and France and Italy passed similar laws in 1898 and Russia in 1903. The first compensation law in the United States was enacted by Maryland in 1902, but it was so restricted in its coverage and so meager in its benefits that it had little practical effect. By 1907 the total accident death rate in the United States was the highest it has ever been—93.7 for each 100,000 of population, despite the fact that this was before motor vehicles had begun to take any appreciable toll. In 1908 Congress passed a workmen's compensation act providing limited benefits for certain federal employees. Massachusetts was feeling its way with an experimental compensation act, and other states were improving their employers' liability acts, all of which were forecasts of the Workmen's Compensation Act passed in New Jersey July 4, 1911, the oldest law of its kind now in force in this country. Seven states passed workmen's compensation laws in 1911, three in 1912, eleven in 1913, two in 1914, and ten in 1915.

Workmen's compensation legislation differs from employers' liability in that it requires the employer to remunerate injured employees whether or not negligence can be proved. Claims under compensation are increased greatly both in number and in size. The costs of industrial accidents became much greater. Whereas, under employers' liability, plant owners investigated accidents for fault, under the compensation acts fault ceases to be an important factor, and owners therefore turned their attention to cause and prevention.

National Safety Council.—In 1912, in Milwaukee, Wis., a small group of men interested in safety work gathered together under the auspices of the Association of Iron and Steel Electrical Engineers, which had been founded in 1907. This group was composed of representatives of industrial corporations, government departments, insurance companies, and other interests, and they decided that by exchanging ideas on a cooperative basis, much greater headway could be made in the control of accident-producing conditions. From this meeting evolved the idea of a great national association that would act as a clearinghouse for the best ideas in accident prevention. A larger convention was called in New York City for the following year, and at this meeting the National Council for Industrial Safety was formally organized. The first activities of the council were directed chiefly toward the reduction of industrial accidents. But, owing to the growth of the organization and the extension of its scope into the field of public safety, its name was changed in 1915 to the National Safety Council, and its constitution was altered to include a national program of public as well as industrial safety.

It is interesting to note that although the council was organized with a roster of only 14 members, during its first year the membership increased to 971. From 1912 on, the organized safety movement has continued to advance.

Local Safety Councils.—About 1918 the first community safety councils were successively organized in Philadelphia, Detroit, and Rochester. Before 1917 all such local councils were volunteer groups with nonpaid officers. The first paid manager was installed at Pittsburgh in 1917. Charters were authorized by the National Safety Council or parent body, but none was actually issued to a local council until July 24, 1925, at which time all active councils received charters.

By 1925 more than 50 local organizations were doing excellent work in accident prevention. There seems little doubt that the total number will continue to increase until all progressive cities have active safety councils.

American Society of Safety Engineers.—Establishment of the American Society of Safety Engineers was another step forward in organized accident prevention. Although the name of this society was not incorporated (under the laws of the state of New York) until 1915, the body was already several years old by that time. In 1909 a safety organization in New York City, called the United Association of Casualty Liability Insurance Inspectors, began holding monthly Saturday afternoon meetings in various insurance company offices. The advent of workmen's compensation insurance greatly increased the interest in this group, and occasional meetings were held in the Grand Opera House. Because of its bylaws, none but insurance men could become members, and, since safety engineering was rapidly attaining a wider scope, the society was reorganized in 1914, and opportunities were established for a larger membership and a wider scope of activities.

This development brought attention to the possibility that there might be a duplication of safety work between the New York body and the Engineering Section of the National Safety Council. To avoid possible misunderstandings, officers of the A.S.S.E. and of the National Safety Council met in November, 1919, to discuss the relationship between the two bodies. Other meetings followed, and it was finally agreed that the most practical solution was to consolidate. In August, 1924, the American Society of Safety Engineers—Engineering Section, while retaining its identity, became an organic part of the National Safety Council.

The objective of this society is the promotion of the arts and sciences connected with safety engineering. Its members are individuals who qualify as safety engineers by education and practical experience. The society sponsors and assists in such activities as regional conferences, safety courses in engineering colleges, formulation of safety codes, and safety research. It is closely associated with the American Society of Mechanical Engineers and other technical societies. Chapters are maintained in several of the large cities. The membership runs well over one thousand.

PROGRESS IN SAFETY ENGINEERING

If a line of chronological demarcation were drawn between the eras of sporadic and of organized accident-prevention work, it would probably indicate the year, 1912. It was in that year that workmen's compensation really got under way, and it was also in 1912 that the first estimates of total industrial accidental deaths were prepared. This estimate was 35,000, a figure that has now been reduced by more than half. It was also in 1912 that manufacturing, insurance, and other interests got together and formed the National Safety Council. Since 1912, however, there have been many momentous events well worth recording.

Following 1912, by no means all employers considered accident-prevention work an inherent part of routine in industry. When they gave safety consideration it was still as a separate factor, one to be handled by specialists such as insurance engineers or specially appointed men in their own companies.

Throughout these varied efforts, and directly affecting their success, ran a thread of misunderstanding, namely, that accident prevention was not a real business issue and that it was outside the realm of industrial routine. The control of accident occurrence was assumed to be something that depended upon the whim of the employer and upon his individual consciousness of moral responsibility for his employees. In fact safety was generally considered as almost purely humanitarian and as having no particular business significance.

As stated previously, paid claims under compensation laws increased greatly in number and in total cost, and as a consequence the economic aspect of accident prevention began to assume greater significance. Also, more data with regard to accident-producing conditions became available with the advent of workmen's compensation laws.

Insurance companies, in waging their campaign against accidents, sought various means to arouse interest and obtain necessary cooperation from employers. Some practical incentive to supplement the humanitarian motive was found to be desirable.

Merit Rating.—An incentive of this kind was created through the development of compensation-insurance rating plans that permitted the allowance of credits for superior plant physical conditions, for the existence of plant safety organizations, and for favorable loss experience on individual risks. Although these plans were originated chiefly for the purpose of accurately measuring the hazards of individual plants, they also had the effect of encouraging accident prevention.

Closer competition in industry, the introduction of newer and speedier methods of manufacturing, replacement of men by machines, a greater sense of responsibility for the safety of employees on the part of employers, and the incentive for a more general use of mechanical guards afforded by insurance-rating methods, brought about a reduction of machine-hazard exposure. Thus, merit-rating plans became less and less effective, and persons interested in accident prevention came to realize that progress was no longer being made at the proper speed. The resulting tendency therefore was to place more and more stress upon the education of employees and upon the value of industrial safety organizations. This trend was obviously in the proper direction, and further progress was made, but even these educational efforts failed to produce the fullest results. The reasons for delayed progress seemed to be: (1) the old incentive was no longer strong enough; and (2) the remedies were not specific, that is, they did not *directly* attack the conditions that were producing injuries.

It was obvious that industry required a more effective incentive than was now available. President Hoover, while Secretary of Commerce, directed attention to the economic value of accident prevention in his study of ways for the elimination of waste in industry. Also, in 1926, it was determined from a most interesting research by The Travelers Insurance Company that the actual amount of money paid by the employer, either directly or through his insurance carrier, for claims and medical expenses resulting from accidents, represented but one-fifth of the total cost of accidents to the employer. The remaining four-fifths of the cost of accidents was found to result from the effect of accidents upon organization, morale, quality, volume of production, etc., as explained elsewhere in this book. This cost study is now commonly referred to as the "four-to-one" cost of accident ratio. It has provided a much needed economic incentive to accident-prevention activity, and encouraged the coordination of accident-prevention activity with plant operating methods. The importance of this study was confirmed by a report of the American Engineering Council on accidents and production in 1927, which showed clearly that accidents have a direct effect on production costs.

Causes of Accidents.—Experience has shown that the application of a remedy for accident occurrence, if it is to be effective, should be directed at the immediate cause of the accidents. Difficulty was experienced in correcting accident causes in some plants because of the scarcity of cause data. Fatalities and major injuries provided insufficient material to permit accurate conclusions as to predominant causes and necessary cures. The facts relating to minor injuries were thought to be of too little value to record. In 1929 "The Foundation of a Major Injury" published by The Travelers Insurance Company showed that in a unit group of 330 similar accidents, only 1 results in a major injury whereas 29 result in minor injuries, and 300 cause no injury whatsoever. The realization that causes were alike for the entire unit made it no longer necessary to await the one serious accident before effecting the necessary correction for the entire group so that the eventual serious accident could be avoided.

Thus accident prevention has progressed, and it is now clear that it should be an inherent activity of business management, not only because it is a worth-while humanitarian work, but also because it results in economic savings of considerable importance. Routines and procedures necessary to attack and control the accident problem, after an analysis has disclosed the causes and remedies, exist in every well-managed plant. It has been demonstrated that the conditions that cause accidents likewise result in defective product, decreased production, inefficiency, and lack of economy generally. Inasmuch as employers are able to control the quality and volume of product by existing methods, they are likewise able to control accident frequency.

APPENDIX III

A MESSAGE TO FOREMEN[1]

Seventy-five years ago, a young man less than twenty was engaged as a divisional railroad-telegraph operator at a salary of $35 a month. His authority and apparent responsibilities were limited. He was ambitious, however, and with a view to the future not only mastered every detail of the work assigned to him but also gradually acquired a comprehensive knowledge of the operation of the entire railway system. One morning the general superintendent of the division was late in arriving at his office, and in his absence an accident had occurred. Immediate and decisive action was required. By virtue of his thorough knowledge, the young telegraph operator grasped the situation and, realizing the necessity for someone to assume responsibility, took charge at once. There was only one track on this particular division, and freight trains were waiting for the express, which had the right of way. He telegraphed to the conductor of the express ordering him to give the freight trains three hours and forty minutes of express time, and asked for an acknowledgment. He then wired to the conductor of each freight train to proceed—thus clearing up a situation that might have resulted in confusion, delay, and loss of revenue.

The subsequent progress and development of this young man, in the business world, were truly phenomenal. Advancement to increasingly important positions convinced him that the acceptance of responsibility is a vital factor in industrial leadership. He became an employer (giving profitable work to thousands of men and women) a financial power, a steel magnate, and a multimillionaire. He endowed charitable and educational institutions, and his death, at a ripe age in 1919, was mourned by the whole world.

The biographies of eminent and successful men of past generations are replete with illustrations of the same kind. Prominent men of today believe in responsibility and accept and practice it. Dodging responsibility, or "passing the buck," is practically an unknown quality in the make-up of successful men. They believe in Gantt's dictum, that "the authority to issue an order involves the responsibility to see that it is properly executed."

One of the many successful men who have worked in supervisory capacities as foremen or leaders while making their way to the top said: "Good management is of more avail than perfect equipment. Napoleon stated

[1] Heinrich, H. W., *The Travelers Standard*, vol. XVII, No. 12, p. 247, December, 1929.

that "Every private carried a marshal's baton in his knapsack." He was speaking of soldiers, but the same principle applies to industrial workers. The baton of a successful executive—namely, the recognition of his responsibilities and the will to accept them—lies in the hand of every foreman.

One of the most important industrial problems is that of training men in the habits of industry—safe and efficient habits. We need not lay so much stress on results of a temporary nature, if our methods are correct. The new worker follows the habits of the older men and of his foreman; therefore this training must be done largely by foremen.

Genius is but the capacity for taking infinite pains. Success depends upon intelligence and hard work, and above all, with regard to industrial leaders and executives, it depends upon the ability and willingness of the individual to accept responsibility.

A supervisor or a foreman stands upon the first rung of the executive ladder. Because of certain valuable personal qualities, he has been selected to direct the work of other employees. Unfortunately, in the average case he enters upon this phase of work uninstructed in the art of executive leadership—and works into it so gradually that he may not realize that his functions as an executive have become markedly different from those of an employee without authority. Sometimes an employee is selected for a position of authority merely because he is a more skillful workman than his neighbors, and in such a case the choice may prove to be an unwise one. It is important to pick the man for deeper reasons than this; for the intelligence of the foreman, and his vision, leadership, executive qualities, and ability to interpret the principles of the concern that he represents may be highly important factors in the profit or loss of a business, and in the prestige, smooth functioning, efficiency, economy, and ultimate success or failure of the organization.

We read of the "man behind the plow"—of the lowliest laborer—of the capitalist, the professional man, the artist, and the scientist. All are eulogized. But O, for the skill of the Hoosier Poet, to picture in homely verse the real *key man* of industry—the hub of the masses—the *foreman!*

Human intelligence is valuable only as it is used. We are told that not more than one one-thousandth part of the average brain capacity is actively employed at any one time. If this is true, then a man may become an outstanding success by putting just a bit more of that "gray matter" to work than does his neighbor. In no place or position in the world is there a better opportunity to show results and win success, than in foremanship. Common sense, logic, initiative, and acceptance of responsibility are all that are required. We take loyalty, knowledge of the job, and work capacity for granted, for without them no man has any right to accept wages or salary from an employer.

Thousands of employers have thought and said, at times: "Show me a man who does what he is told, and does it intelligently, and I'll show you a man who will be successful." Likewise, I say: "Give me a foreman who can accept responsibility, and I'll show you a man who will get results." What is there about responsibility that makes it so hard to accept? Nothing but unwarranted fear—fear of failure, fear of consequences. It is true that every man who tries may fail, and that every man who leads must accept the consequences. Bear in mind, however, that straddling the fence gets us nowhere, and that in accepting responsibility we at least expose ourselves to the probability of winning sometimes; and when we *do* win, the consequences that we were so afraid of turn out to be happy ones. Fear to accept responsibility is rank pessimism. If we are afraid, it is because we think we can't win.

Fear to accept responsibility keeps more good men in subordinate positions than any other one factor.

A live-wire superintendent once said to a trusted foreman: "Go ahead and set up this job and turn out the work." What an opportunity for a good foreman! In this case, however, as in many others throughout industry, a series of questions followed, instead of action. The foreman wanted to know when to start, what men to use, where to get the tools, and how soon the job was wanted. He complained, also, that he would have to neglect other work if he did this job, and, in fact, placed the entire burden of responsibility right back upon the superintendent, who was obliged to supervise the job himself. Now, bear this in mind: *The job was done.* Work was redistributed so that the new job could get under way without disrupting the regular production schedule. All the trivial questions and objections raised by the foreman were ironed out—*but not by him.* By the superintendent!

If the foreman had understood responsibility and been willing to accept it, he would have realized that here was a fine opportunity to advance his own interests. Instead, his negative attitude clearly showed that he was not yet ready for a position of authority.

The reaction of the superintendent to the foreman's failure to assume responsibility was one of disappointment, irritation, and dissatisfaction. Said the Scotch poet:

> "O wad some Power the giftie gie us
> To see oursels as ithers see us."

Foremen of America, think over this idea of accepting responsibility. There's meat in it—yes, money and success.

Of all the time-wasting, irritating, and costly situations that bedevil the life of the busy executive, there's none so trying as that which is brought about by the foreman who isn't a foreman and who places on the executive's shoulders the burden of responsibility that he, himself, is paid to assume. Foremen are paid to run their departments and to supervise their men. Common sense dictates "go ahead and do it—and do it with intelligence."

There's another and more cheerful side to the picture. A foreman was called into conference on a most difficult production problem. The management was extremely anxious to accept a large order for a certain product, for the manufacture of which the machinery in the plant was not designed. The executives were frankly skeptical of their ability to do the work and called in the foreman of the automatic-screw-machine department—chiefly to have him confirm their doubts. With an air of kindly tolerance, the general manager said: "Jones, can we turn out 10,000 of these pieces in one month?" To the intense surprise of the men in conference, Jones said, after carefully studying the sample: "Yes, we can fill that order. Shall I start at once?"

"Now wait a minute, Mr. Jones," came the answer. "Frankly, we thought it was impossible. How do you propose to go about it?"

"Well," said the foreman, "it's an unusual job and won't go on our standard machines; but we still have those special turret lathes that were taken out of the department when we reorganized, and they will handle the job nicely. I'll have them set up again if you say so. The cost will be nominal. We'll have to have some special cutters made by the tool department. The wooden handles can be bought in town, and the assembly can be done here. We'll need a precision gauge of special make, and an extra operator whom I can borrow from Building B, where work is a bit slack just now."

Summing it all up, the foreman displayed a knowledge of the business and an intelligence that were gratifying and surprising. Further, he seemed to know so much about how the job should be done that he was allowed to do it. Not only did he fulfill his promise with regard to his own part of the work in the automatic-screw-machine department, but in addition, he gave such evidence of executive ability that he was authorized to deal with the novelty woodworking plant for the purchase of handles and also to supervise the assembly, finishing, and testing operations.

Jones is now assistant general works manager of this plant. He was a good foreman; he knew how to accept responsibility. Suppose he had failed. But why suppose? Know your job, and then go ahead and accept responsibility and you cannot fail. That is what Jones did, and you, too, can do it just as well.

Industry must have capital. It also needs the services of inventors, scientists, mathematicians, and engineers. It must have executives, salesmen, and production managers. Employers there must be, if employees are to receive remuneration; but the hub of the wheel, the heart of the industrial situation, is the man who personally directs the work of the employees. By whatever name he is called—foreman, supervisor, gang-boss, head man, or strawboss—there is after all only one man who tells the worker what to do and how to do it and sees to it that the work is done; and that man, whom I refer to herein as a foreman, controls his own fortunes and plays an important role in the success of the organization of which he is a part.

Responsibility—the hallmark of success! Accept it and succeed. Do not waste time on matters of finance or personnel when they are outside your job, but remember that practically all operations and methods of procedure are related to your work, in one way or another. Learn about them and become familiar with them. Be ready, always, to take the job of the man next higher up. Take advantage of the opportunities that so often come to persons with a sense of responsibility; and in accepting responsibility do not fear that you will be alone. The higher pay that accompanies the better positions may not require more manual labor—but *it must be earned;* and one way to earn it is by accepting responsibility whenever the opportunity offers. The superintendent and works manager, the production and sales heads—yes, the president of your company himself—must accept responsibility. Your mistakes are their mistakes. Your success is their success. The board of directors or the stockholders must have an accounting with someone for everything that goes on.

Do you suppose that any high executive officer would dream of saying to a board of directors: "I'm sorry, gentlemen, but I am not to blame. That big order was lost because one of my foremen turned out a batch of goods of inferior quality." This executive directs the employment of the men—their training and instruction—he provides the tools and enforces supervisory methods, and is responsible for events that occur even while he is away from the plant.

How about *you?* You, as a foreman, know your men; you personally instruct and train them; you are on the job, and have the best opportunity in the world to correct improper practices before they cause trouble. Don't make the mistake of dodging responsibility—and bear in mind that that goes for *everything* that happens in the conduct of the work under your supervision. Accidents, for example, are your responsibility, just as much as errors are; for, in fact, accidents really *are* errors. Production and quality of work are your responsibility; so are discipline, order, morale, and good housekeeping.

Injuries resulting from accidents occur far too often. Thousands of lives are lost, and immeasurable suffering exists because of accidents. Billions of dollars are lost annually. You and all other purchasers, and the consuming public in general, pay these losses in the prices charged for food, clothes, shelter, and the other necessities and luxuries of life. Research proves that 98 per cent of your accidents are of a preventable type, and that 88 per cent of them are due not to unguarded machinery but to supervisory conditions within the control of the foreman. Accidents represent man failure, and the foreman is the one person in industry who knows how to control men.

Do you realize that the real causes of accidents are likewise the causes of inefficiency, poor economy, poor production, and poor business generally? They are. Here are some of them: Failure to issue and enforce instructions, inattention, poor discipline, improper and unsafe practices, inexperience, and undue haste. Are not these conditions the very ones that you, as a foreman, are fitted by experience to control? Moreover, you actually *do* control them when they affect the volume and quality of the work. Suppose you are asked to fill an order for a certain number of units of production, and when you are giving instructions to your men one of them says that he can't follow them because he is too busy; or suppose that he does follow the instructions halfheartedly and makes mistakes or spoils much valuable material. Quite properly, discharge or other severe penalty is the very last remedy you would resort to, yet you as a foreman—a leader of men—do not admit failure. You "get results" by one means or another. The work goes along, difficulties are ironed out. By applying true foremanship the job is done, and done properly. In carrying on your work successfully, you are controlling the conditions that affect profitable production.

Bearing in mind that these conditions are likewise the ones that produce injuries, it is obvious that you can control accident occurrence just as readily as you can govern defects and volume of production. This fact becomes more obvious when it is recognized that a serious injury is not an isolated happening by itself, but is the logical consummation of some 329 other precisely similar accidents, all of which have the same cause, but 300 of which do not result in actual injury. The employee who is injured as the result of an accident has, in the average case, made the very same mistake or the same error of judgment—violated the same instruction or taken the same chance—that finally caused the injury, many, many times before without, however, having been hurt. There lies the opportunity of the foreman to control accident frequency. There, in the foundation of injury—*the accidents that have not yet caused injury*—is the place to direct an attack. Injuries are like water over the dam. Learn from them, but go to work upon the "injury in the making"—one of the 329 accidents which, in the average case, precede every serious injury. These are all visible occurrences and may readily be observed and corrected before trouble arises.

Keep this ratio of accidents to injuries in mind when next you hear the assertion, "This is the first time an accident of this kind ever happened." It may be the first time a serious *injury* occurred from that cause, but there have undoubtedly been hundreds of similar *accidents*, which fortunately produced no injury; and these may be observed and checked by the very man who should hold himself responsible for them—the foreman.

We need to note the difference between blame (or guilt) and responsibility. A foreman need not hold himself morally *guilty* when an employee in his charge is injured, but he cannot and should not evade *responsibility* under any circumstances whatsoever.

Remember that *the authority to issue an order involves the responsibility to see that it is properly executed.* The country depends upon you—the key man of industry, the foreman—to maintain that leadership among nations, of which we are so justly proud, in the safe, peacetime development of industry.

APPENDIX IV

PRIMARY CAUSES OF ACCIDENT PRONENESS

THE ACCIDENT-PRONE EMPLOYEE

Organized accident-prevention work was first undertaken by The Cleveland Railway Company in 1923 under the supervision of the operating

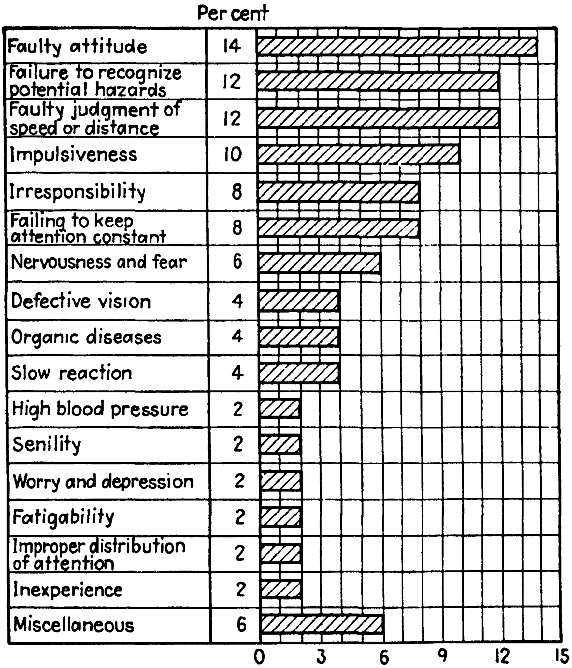


FIG. 1.—Percentage distribution among 50 motormen. Woodhill Division, The Cleveland Railway Company.

department. Following the creation of the personnel department, the work was placed in charge of a supervisor of accident prevention, who was assigned thereto.

Safety work has heretofore comprised on the one hand physical improvements in right of way and equipment to provide greater safety for patrons, and, on the other, educational effort among employees designed to encourage safe operation. The former activities have consisted largely of the removal of physical defects in certain types of car equipment, in putting into operation so-called "safety" cars and in the installation of modern traffic control equipment throughout the city in cooperation with local authorities. As a part of the educational effort, a trainmen's safety committee has been organized at each station, a suggestion system installed, and safety contests conducted among the various operating divisions.

During the course of this work from 1923 to 1928 the company has steadily reduced year by year the number of collision accidents in which it has been involved, in spite of a large increase in automobile registration in Cleveland during this period, which has been accompanied by a similar increase in motor vehicle fatalities as shown in Fig. 2. For the year 1928 this reduction

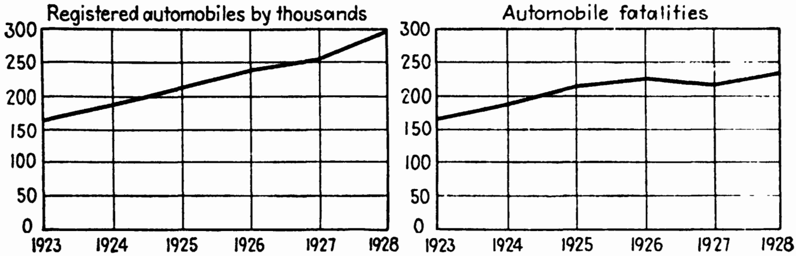


FIG. 2.—Registered automobiles and automobile fatalities in Cleveland, Ohio, 1923–1928.

reached 22.3 per cent, as compared with the average of the preceding five-year period.

Individual Susceptibility to Accident.—Notwithstanding this improvement in accident experience, the system record clearly indicated that general educational safety work failed to accomplish results under certain conditions. This was particularly the case at Woodhill Station, which during 1927 and 1928 experienced a steady upward trend in accidents compared with the records of other divisions, as shown in Fig. 3.

Analysis of the accident record at this station, which was selected for the first or experimental accident-prone study, led to the discovery that a relatively small group of motormen were involved in a large percentage of all accidents reported, although operating under practically identical conditions as the other larger group of trainmen whose accident records were, in most cases, excellent.

This finding apparently confirmed statements of psychologists and psychiatrists that accidents do not distribute themselves by chance, but that they happen frequently to some men and infrequently to others as a logical result of a combination of circumstances. Those individuals who because of certain mental, psychological, or physical defects fail to control a situation leading to an accident when it arises usually become involved, whereas those possessing the necessary physical and mental requirements show little susceptibility to accident.

There is an increasing tendency, therefore, to consider the occurrence of accidents as an individual problem rather than as a situation to be controlled entirely by means of educational work among a group at large. Just as a physician diagnoses and treats a chronic ailment to effect a cure, so those employees who are repeatedly involved in accidents or are *accident prone* are being studied and treated individually in the belief that many of them

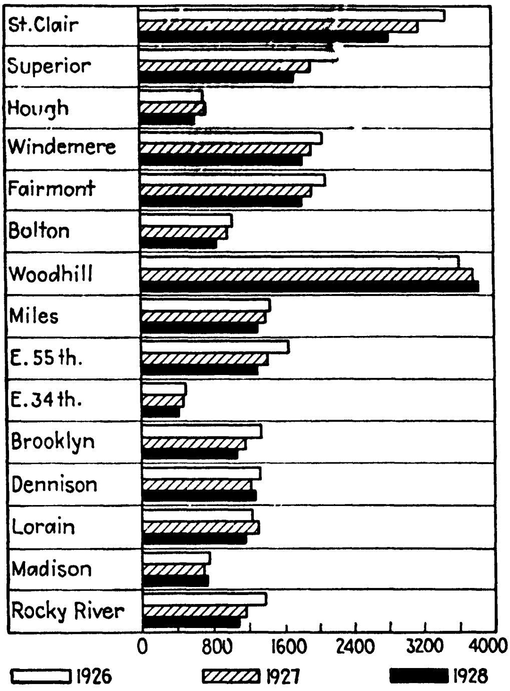


FIG. 3.—Reportable accidents by stations prior to study of accident-prone men. The Cleveland Railway Company, 1926–1928.

may be adjusted properly and become assets rather than liabilities. Case-study methods, while reducing accident frequency among the small group of high-accident men, tend at the same time to encourage the entire group of employees to improve their records by breaking down the age-worn theory that accidents are a matter of "hard luck" and that they cannot be prevented.

Getting the Facts.—At the beginning, investigations at Woodhill Station were confined to motormen. To determine accurately which of these were high-accident, or accident-prone men, the 1928 record for each motorman at the station was compiled. Accidents from all causes were included in determining an individual's record, so that all contributing factors might be given consideration. To make allowances for variations in length and character of runs, number of days off duty and other similar factors, the accident record was related in each case to the total number of car miles operated and a *frequency rate based upon the number of accidents per* 1,000 *car miles determined.*

The average rating for the 167 motormen of the station was found to be 0.86 accident per 1,000 car miles; 75 men ranked above average and 92 below. The first 50 of the 75 men above average or those having a rating of over one accident per 1,000 car miles were considered as *accident prone* for purposes of the study.

Had the 50 high-accident motormen been selected merely on a numerical basis of accidents without reference to mileage operated, men whose records were below 24 accidents for the year, 10 of whom were included in the selected group, would have been given no consideration.

Further study showed that the selected group of men, comprising nearly 30 per cent of the total number of motormen at the station, had been involved in 44 per cent of all accidents reported. Hence if the accident records of these relatively few men were cut in half, presumably the recurrence of one quarter of all accidents reported the previous year would be prevented.

Accident and Service Records.—To make available for study as complete information as possible, the 1928 service and power consumption records of all Woodhill Station motormen were prepared. These data and the ratings mentioned above, comprising a complete accident and service history, were transferred to an individual record card Form 1, upon which was posted weekly the corresponding current information as the study progressed. The maintenance of such a card index system not only made readily available all of the facts concerning each motorman's past record but also enabled those engaged in the study to keep a close check upon accident-prone cases as treatment of them progressed, noting improvement or lack of improvement by comparison with the previous year's record.

General Findings.—Although these data were used primarily for purposes of individual case study, they also permitted reaching certain general conclusions regarding factors contributing to accidents. To determine whether any significant relationship existed between length of service and accident frequency, the combined accident ratings were computed for motormen grouped according to length of service. Figure 4 shows that, with the exception of a few service groups, accident records tend to decrease with experience. For example, men with five to ten years of experience showed a combined rating of 0.84 accident per 1,000 car miles, while those having less than five years' service had a rating of 1.14, or 36 per cent higher. These facts seem to indicate the need, from an accident-prevention standpoint, of *more thorough training of new employees before they are assigned to runs.*

That motormen who produce unsatisfactory accident records also tend to consume an excessive amount of power was brought out by a comparative study of power consumption and accident frequency. The amount each man on each run varied above or below the average amount of power consumed by all motormen, operating similar runs during the same period of time, was computed for the year 1928, in terms of kilowatt hours per car mile and then related to his accident rating. This relationship is presented graphically for each of the group of 50 high-accident men in Fig. 5, which shows that 35, or 70 per cent of the men whose accident ratings were above average, consumed more than the average amount of power. This finding apparently confirms the belief that unsafe operation is usually inefficient operation as well.

A study was also made of individual service records as measured by the number of delinquencies in reporting for work, the days of discipline, and

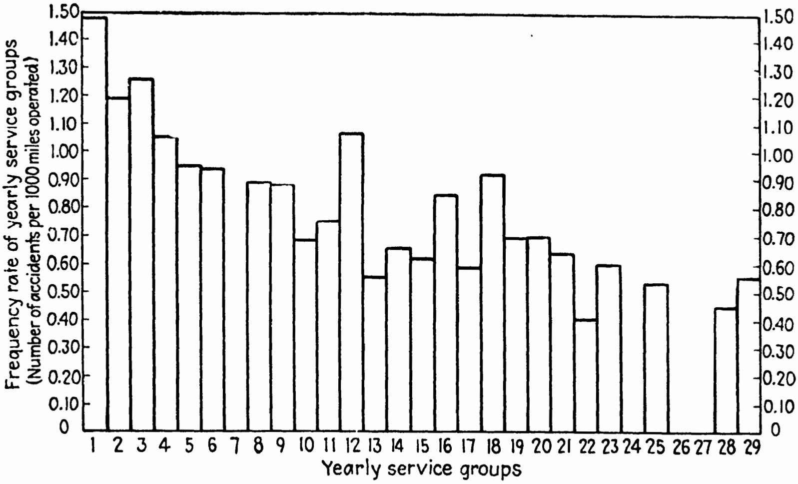


FIG. 4.—Comparison of accident-frequency rates and length of service among 167 motormen. Woodhill Division, The Cleveland Railway Company, 1928.

the days of absence on account of illness. Little relationship existed between these factors and accident frequency.

Case Studies of Motormen.—After obtaining these data, quarters were established at the offices of the selected station, and meetings of trainmen, irrespective of accident record, were held in order fully to acquaint them with the nature and purpose of the proposed program. The men were informed frankly that a careful review of the accident situation at the station had been made because of an unsatisfactory record during the past few years and that it had been found certain men were high and others low in accident performance. It was stated that, as a result, the accident prevention department proposed to discover and remove, if possible, the causes of accidents among the high-accident men for the purpose of helping them in a constructive manner to improve their records and consequently to improve the standing of the station. Each individual's cooperation in the study was sought, as no attempt would be made to fix liability for accidents.

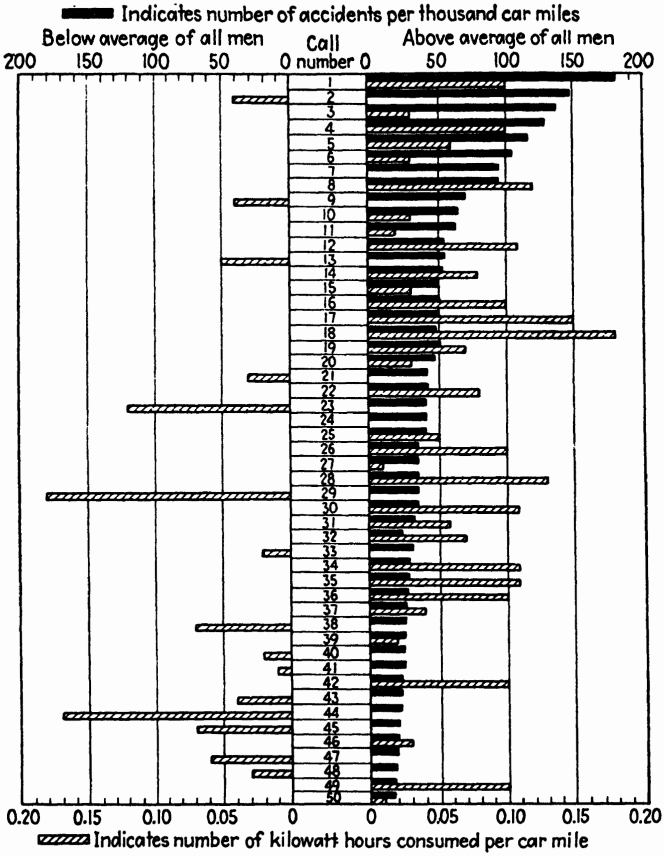


FIG. 5.—Comparison of accident-frequency and power-consumption rates among accident-prone motormen. Woodhill Division, The Cleveland Railway Company, 1928.

The methods employed in studying each accident-prone case may be classified roughly as follows:

a. Observations of operation.
b. Analysis of previous and current year's accident record.
c. Personal interview.
d. Decision as to primary causes of accident proneness.
e. Preparation of report of case, recommending treatment based upon the findings.

Observing Operation.—To determine accurately the subject's operating habits and characteristics under average conditions, observations were made of his work both with and without his knowledge by two or more trained individuals. The term "characteristic" was used to define mental factors as contrasted with the term "habit" which referred specifically to

MOTORING RATING FORM

Accident-prone case number................Badge number...........
Car..........Line..........Date.........Time........to.... ....
GENERAL OPERATION:
1. Starts: Smooth......Jerky......Looks to right and left......
2. Stops: Smooth......Jerky.......
3. Use of Air.............Sand.......
4. On Time: Sharp........Late........If late, why?.............
MOTORING HABITS:
5. Loading and unloading....................................
6. Control passing principal intersections.......................
At other danger points.............On curves.................
Past standing cars.................With children near? ....
7. Following traffic too closely?........How closely..............
8. Crowding traffic lights?.....................................
9. Use of warning signal.......................................
10. Coasting on down grades?...................................
11. Attends closely to bell?............Reaction.................
12. Watching for prospective passengers?.........................
13. Particular attention to vehicles on right?......................
14. Watching traffic at considerable distance?. ....
MENTAL FACTORS:
15. Attitude toward job...........Toward passengers............
16. Understanding of traffic hazards..............................
17. Judgment of speed of vehicles.............Distance............
18. Distribution of attention....................................
19. Attention constant?..
20. Distraction?...
21. Reaction: Rapid?.................Sluggish?...............
22. Nervous?..........Worried?..........Impulsive?............
23. Irresponsible?..................State of hurry?.............
PHYSICAL FACTORS:
24. Eyesight...........Hearing...........Overweight?.........
25. Posture............Fatigued?..........Senile?..............

FORM 2.

operating practices. Factors in operation considered of greatest importance as contributing causes of accident were itemized upon a specially prepared form (Form 2), copies of which were furnished observers as a guide. It will be noted that these various factors were classified for convenience under four main headings.

Causes of Accident Proneness.—All of the facts developed in each case as described heretofore were analyzed, coordinated, and interpreted.

PERSONAL INTERVIEW FORM

Accident-prone case number................Badge number........
Date of interview................. ....Age................ ..
Date of employment.......................Years in service. .. ..
Line................Run number..........Hours on duty..

(*Information to be supplied by subject*)

PERSONAL DATA:
Home address..................Own..........Rent..........
Married?................Age of children............ ....
Other dependents...................................
Birthplace...........................Raised..... ....
Schooling..
Former occupations.......................... ....
Economic status...................................
Health......................Sickness previous year........ ...
Home conditions...................................
Interests...................... ....
Difficulties..... ....

ACCIDENT DATA:
Total accidents last year..................This year.........
Total accidents for which he was blamed last year....This year..
Last major accident................Type.....................
Cause..
How could it have been prevented?............. ... .
Principal causes of accidents.......................... ...
When do they occur?.............. ....
Principal operating difficulties.......................... ..
Suggestions for correcting them....................... ..

IMPRESSIONS OF INTERVIEWER:
Attitude toward job and company......... ....
Possible causative factors of accident:
Physical..
Mental..

FORM 3.

Finally conclusions were reached as to the fundamental causes of accident-proneness, which served as a guide in subsequent treatment, particularly in those cases demanding retraining.

No two cases were found to be similar. In most instances several causes existed, although in each case one of these was found of primary importance. For practical purposes, however, all causes were grouped under the three headings: physical factors, mental factors, and operating defects.

In Fig. 1 the percentage distribution of the primary causes of accident-proneness among the 50 cases is presented graphically. "Faulty attitude" was found to be the principal primary causative factor of accident, as it was present in 14 per cent of the cases studied.

Should a case fail to show adequate improvement following treatment, the facts were reviewed again or additional investigations were made if necessary, to determine whether the diagnosis had been faulty.

Report of Clinical Study.—A report summarizing the facts established in each case and recommending treatment based upon the causes of accident proneness which these findings disclosed was prepared and submitted to the operating department.

Treatment.—For purposes of treatment, cases were divided into three main groups: *Medical problems, personality problems, and faulty operation problems.* The reports mentioned previously, together with the description given below, illustrate the methods adopted in treating each of these types of cases.

Medical Assistance.—Physical difficulties were found of primary importance in 12 per cent of the cases, classified by causes of accident proneness in Fig. 1 under the headings "defective vision," "organic diseases," "high blood pressure" and "senility." When the presence of physical defects was suspected, a physical or eye examination was given as determined by the case, and proper treatment was prescribed. For example, the general physical condition of one motorman warranted an examination, inasmuch as his ailment was a chronic complaint. Diagnosis revealed a case of chronic appendicitis. During the three months following his return to work after an operation in which the company assisted financially, an improvement of 45 per cent was noted in his accident record, with the result that he has disappeared entirely from the high-accident group. In another case high blood pressure was discovered. After following the doctor's advice for three weeks, the pressure had been decreased ten points and the condition apparently was corrected.

Two motormen were found with defective vision. In one case glasses were prescribed, and the subject's record has shown a decided improvement. In the other a cataract was discovered on the left eye of a motorman, rendering him blind in that eye. A transfer to the position of conductor was arranged until such time as an operation could be performed.

Personality Readjustment.—In 22 per cent of the cases an improper mental attitude or personality defect was found to be the primary causative factor of accident, as shown in Fig. 1, classified according to "improper attitude" and "irresponsibility." The men in this group were referred to the superintendent of transportation, who in an interview carefully reviewed the facts reported in each case. An effort was made to give the subject a clear understanding of his personality difficulties and to point out to him frankly why they interfered with satisfactory performance on the platform and what the probable outcome of them would be unless a change in general outlook and behavior on the job were shown. In most cases the man was placed upon probation, varying from thirty to ninety days, and the performance of his work closely watched. At the expiration of that period he was inter-

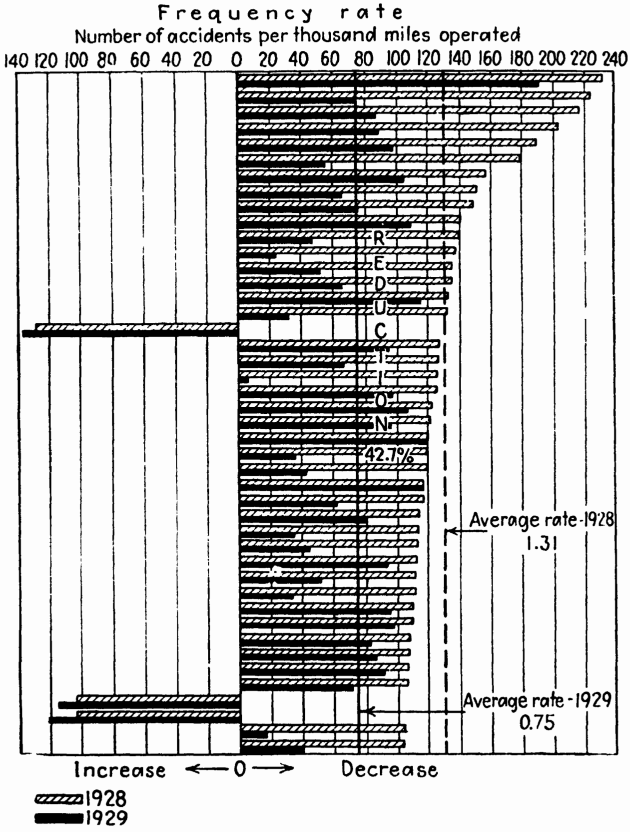


FIG. 7.—Frequency rates for each of 44 accident-prone motormen showing comparison before and following study, 1928 and 1929. Woodhill Division, The Cleveland Railway Company.

viewed again by the Superintendent and disposition was made of his case. With one exception, all have shown decided improvement. In two cases only one slight accident has occurred since action was taken. These facts are significant, since they illustrate the marked influence that apparently unimportant personality traits have in interfering with safe operation, as well as what can be accomplished readily when these "problem" cases are dealt with intelligently and understandingly.

Operating Defects.—The remaining 66 per cent of the cases, by far the largest of the three groups, comprised the men whose high accident records were due primarily to certain operating defects, such as "failure to recognize potential hazards," "faulty judgment of speed and distance" and "improper distribution of attention," as shown in Fig. 1. These weaknesses manifested themselves in such practices as "jerky starting and stopping," "following traffic too closely," "no attention to cut-ins," "failure to watch boarding

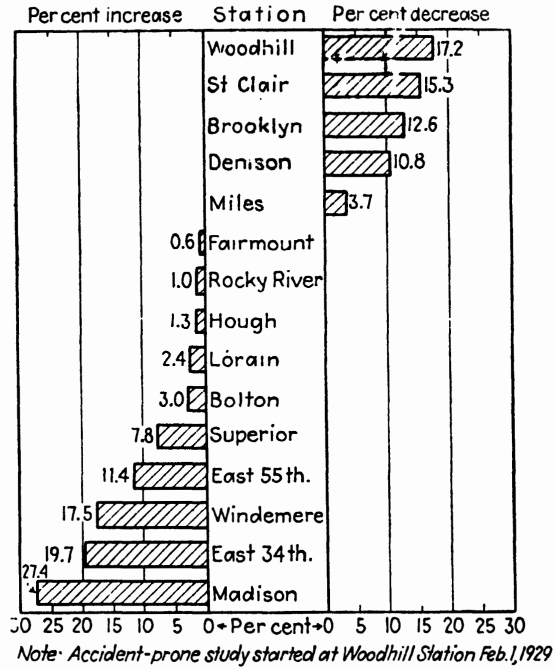


FIG. 8.—Increase and decrease, total number of accidents Feb. 1–July 31, 1929, as compared with Feb. 1–July 31, 1928, by stations. The Cleveland Railway Company.

and alighting passengers" and "crowding into traffic unnecessarily." Reinstruction or special platform training was provided each of these men to correct the undesirable practices by strengthening the ability or faculty that was found to be weak. If this proved impossible, as was the case among one or two of the older employees whose operating habits had become fixed by years on the road, efforts were made to compensate for the weakness by greater development of other faculties in accordance with the psychological theory of "compensation for specific limitations."

This work was undertaken by a former inspector and motorman, who was appointed and trained as a platform instructor and assigned to the division of training and employment. Reports of the case study, as well as the current accident record of each man, were provided him as a guide.

After an initial contact to obtain the motorman's confidence, the instructor rode periodically with the subject while on duty and tactfully pointed out instances where poor judgment was being used or suggested how certain operating faults he displayed might be remedied. A weekly record of retraining assignments was maintained by the instructor, showing the number of observations he had made and the characteristics or habits he had observed, together with his action in each case.

Retraining was continued until marked improvement was shown. That the program of reinstruction proved effective is attested by the results of treatment in each case, as indicated graphically on page 400 (Fig. 7). It is also interesting to note that after the development of similar work at other stations a reduction in collision accidents has been made only when accident-prone studies have been accompanied by systematic reinstruction. At those stations collision accidents have shown a combined decrease of 19.6 per cent following the work, compared with the similar months of 1928, whereas all others have experienced an average increase of 14 per cent.

APPENDIX V

STANDARDS FOR MECHANICAL GUARDING[1]

18. MECHANICAL POWER-TRANSMISSION EQUIPMENT

18.1 Shafting.—Each continuous line of shafting should be so secured in position as to prevent excessive endwise movement.

Shafting should run without excessive whipping or vibration.

All exposed parts of horizontal shafting six feet or less from the floor or work platform, except shafting in runways used only for oiling or running adjustments, should be protected by a stationary casing enclosing the shafting completely or by a trough enclosing the sides and top or the sides and bottom of the shafting as location requires.

Shafting under bench machines should be enclosed by a stationary casing or by a trough at the sides and top or the sides and bottom, as location requires. The sides of the trough should be carried to within not more than six inches of the underside of the table, or, if the shafting is located near the floor, to within six inches of the floor. In every case, the sides of the trough should extend at least two inches below or above the shafting, as the case may be.

Vertical and inclined shafting six feet or less from the floor or work platform, except shafting in maintenance runways, should be enclosed by a stationary casing.

Exposed shaft ends should present smooth surfaces. They should not project more than one-half the diameter of the shaft beyond bearing or hub unless they are guarded by nonrotating caps or safety sleeves.

Keyways not in use should be covered.

18.2 Pulleys.—Every pulley should be guarded if any part of it is 6 feet or less from the floor or work platform.

Balance wheels (such as on punch presses), may be guarded by disks covering the spokes, unless they are belt-driven and the point of contact between the belt and wheel is less than 6 feet from the floor or platform. In the latter case, the wheels should be enclosed.

Cracked pulleys, or pulleys with broken rims, should not be used.

Pulleys which are permanently out of service should not be allowed to remain on shafting which is in use.

18.3 Belts, Ropes, and Chains.—Where both runs of a horizontal belt are six feet or less from the floor level, the guard should extend to at least

[1] "Handbook of Industrial Safety Standards," National Conservation Bureau.

15 inches above the belt, except that where both runs of a horizontal belt are 42 inches or less from the floor, the belt should be fully enclosed.

Overhead horizontal belts, the lower parts of which are seven feet or less from the floor or platform, should be guarded for their entire length on the sides and bottom.

Overhead horizontal belts which are more than seven feet above the floor or platform should be guarded for their entire length under the following conditions:

If they are located over passageways or workplaces and travel 1,800 feet or more per minute, and

If the center to center distance between pulleys is ten feet or more, and

If the belt is eight inches or more in width.

Where the upper and lower runs of horizontal belts are so located that passage of persons between them would be possible, the passage should be completely barred by a guardrail or other barrier, or, where the passage of persons is regarded as necessary, there should be a platform over the lower run, guarded on either side by a solid barrier or by a railing completely filled in with wire mesh or other filler. The upper run should then be so guarded as to prevent contact therewith by either a worker or objects carried by him.

If the guard or enclosure for a vertical or inclined belt is within four inches of the belt, it should be not less than six feet in height. Openings through the guard which are more than ½ inch in width, and through which fingers might be inserted and so be injured by belt and pulley, should be completely covered or protected by substantial material such as wire netting of not more than ½ inch mesh, made of wire not smaller than No. 16 U. S. Standard Gauge.

If the guard for a vertical or inclined belt is more than four inches distant from the belt and pulley, it should be not less than five feet in height. Such guards, if constructed of wire mesh, should not have openings larger than two inches in size, and the wire should be not less than No. 12, U. S. Standard Gauge. Slatted guards, if used, should not have openings greater than one inch in width.

Guards for inclined belts should be so installed that the vertical clearance between the lower run of the belt and the floor, at any point outside of the guard, is not less than six feet six inches.

Vertical belts running over a lower pulley which is more than six feet above the floor or platform should be guarded at the bottom in the manner recommended for overhead horizontal belts, if they are located over passageways or workplaces and travel 1,800 feet or more per minute, and if they are eight inches or more in width.

The preceding recommendations pertaining to belts also apply to ropes.

Overhead chain and link belt drives, where the chain exceeds two inches in width, should be guarded in accordance with the recommendations made for overhead horizontal belts.

Sprocket wheels and chains should be enclosed unless they are more than seven feet above the floor or platform.

18.4 Gears.—Gears should be guarded by: (*a*) a complete enclosure, or (*b*) a guard at least six feet high and extending at least six inches above the mesh point of the gears, or (*c*) by a band guard covering the face of the gear and having flanges extending inward beyond the roots of the teeth on the exposed side or sides. Where any portion of a train of gears, guarded by a band guard, is less than six feet from the floor, a disk guard or a complete enclosure to the height of six feet should be installed.

It may not be absolutely essential to guard hand-operated gears which are used only to adjust machine parts and which move only when hand power is applied. However, the guarding of such gears is recommended.

18.5 Friction Drives.—The driving point of a friction drive should be guarded if it would otherwise be exposed to contact.

Arm- or spoke-friction drives and web-friction drives with holes in the web should be entirely enclosed.

Projecting bolts on friction drives should be guarded if they would otherwise be exposed to contact.

18.6 Keys and Set Screws.—Keys, set screws, and similar revolving parts should be made flush, should be countersunk, or should be guarded by metal covers. This may not apply to some keys or set screws which are wholly within gear casings, sprocket casings, or similar enclosures.

18.7 Collars and Couplings.—Revolving collars, including split collars, should be cylindrical. Screws or bolts in a collar should not project beyond the largest periphery of the collar.

Shaft couplings should be constructed so that their bolts, nuts, set screws, or other revolving parts will not present a hazard. Bolts, nuts, and set screws should be countersunk where that is possible. In any event, they should not extend beyond the flange of the couplings unless they are covered by safety sleeves.

18.8 Starting and Stopping Devices.—*To assist in preventing injuries, and to assist in limiting the severity of injuries when accidents do occur, it is highly important that there be means of controlling, and especially of stopping, the flow of power from an engine, turbine, motor, or other prime mover to the transmission equipment and to the machines driven thereby. It must be remembered that most prime movers are so constructed that, once they are started, they tend to continue to drive the equipment mechanically connected to them at a nearly constant speed quite regardless of the relatively minor loads imposed by contact of the human body with power transmission equipment or with power-driven machines.*

This section does not include recommendations with respect to starting or stopping devices controlling the prime mover itself. Such material is included in Section 15.

If any mechanical power-transmission equipment or any power-driven machine cannot be readily seen from the point at which the flow of power to it is controlled, effective signalling equipment should be installed and so used as to give ample warning that machinery is to be started.

To provide emergency control of power, transmission equipment should be divided into separate units, and there should be a clutch or equally effective device controlling the flow of power from the prime mover to each such unit. Preferably, no transmission unit from which machines are driven should extend beyond a single room. Clutches and other emergency control devices should be immediately accessible and should be so marked as to clearly indicate their purpose and how they should be operated.

It is recommended that the stopping of the supply of power to each unit of transmission equipment be subject to remote control in addition to control at the stopping device. Remote-control stations should be in such number and so located that power can be shut off quickly by a person starting from any point within the room or area under consideration. The starting of the supply of power by remote control is not recommended.

Every power-driven machine not driven by an individual motor or prime mover should be equipped with a clutch, loose pulley, or similar device for quickly disengaging power. The means for operating such a disengaging device should be so located and so arranged that the operator of a machine can readily reach it and use it from any working position. At the same time, the location and arrangement should be such as will reduce to a minimum the likelihood of accidental operation. A belt tightener is not recommended as a device for engaging and disengaging power.

Hand-operated or foot-operated internal clutches, such as those embodied in some guillotine cutters, power presses, and embossing machines, are not disengaging devices within the meaning of this paragraph.

Each pair of tight and loose pulleys should be equipped with a permanent mechanical belt shifter. Each clutch or starting gear should be equipped with a permanent operating handle.

It is preferable that belt shifter, clutch and gear handles be so arranged that they will hang or stand vertically when the belt is on the loose pulley or when the clutch or gear is disengaged.

In a given shop, all belt shifter, clutch, or gear handles of the same type should move in one and the same direction to stop machines, that is, all to the right or all to the left from the running position. This recommendation does not apply to those clutches, as on countershafts which embody two clutch pulleys carrying open and crossed belts respectively. In such a case, there are three positions for the clutch handle, and the driven machine should be without power when the clutch handle is in the center (or neutral) position.

Every belt shifter should include mechanical means which will prevent the belt from creeping from the loose to the tight pulley.

The shifting part of jaw clutches, and the shifting or mechanism part of friction clutch couplings, should be attached to the driven shaft, that is, to the shaft which will be idle when the clutch is disengaged.

Clutches, cutoff couplings, or clutch pulleys having projecting parts should be enclosed by stationary guards if they are seven feet or less above the floor or work platform.

18.9 General Recommendations for the Construction of Guards.—It is intended that the guards called for in the preceding paragraphs of this section be constructed in accordance with the following general recommendations. Reference should also be made to Fig. 1.

All metal should be free from burrs and sharp edges.

Guard frames should consist of angle iron or iron pipe securely fastened to the floor, the wall, the ceiling, or the frame of the machine. The filling material attached to the frame should be expanded, perforated, or solid sheet metal or wire mesh.

If the uprights used for supports are made of angle iron, the angles should be not smaller than 1 by 1 by ⅛ inch; if they are made of iron pipe, it should be of not less than ¾-inch iron pipe size. Other construction should be of equivalent minimum strength. The sizes of the uprights should increase above these minimums according to the weight and size of the guard, its location with respect to aisles, and the possibility of its being damaged by moving equipment.

Wire mesh should be of the type in which the wires are securely fastened at every cross point by welding, soldering, or galvanizing, except in the case of diamond or square wire mesh made of No. 14 gauge wire, ¾-inch mesh or heavier.

The filling material (expanded metal, sheet metal, wire mesh, etc.) should be securely fastened to the supports. For angle-iron supports, the fastening may be by means of ¾- by ⅛-inch flat iron fastened to the angle by 3/16-inch bolts or rivets placed at intervals not exceeding ten inches, or by means of 1- by 1-inch wooden strips fastened to the angles by 3/16-inch bolts. For pipe supports, the fastening may consist of clamps or of heavy wire. Perforated or sheet metal may be bolted or riveted directly to the supports or may be spot-welded thereto.

For more detailed information on the matters embodied in this section you are urged to procure:

*ASA Code, Mechanical Power Transmission, B*15-1927

19. MOVING PARTS OF MACHINES

This section relates to machines in general and to numerous parts of those machines which are in motion when the machines are in operation. It does not relate to point-of-operation hazards. It is followed by sections pertaining to specific machines and to the hazards peculiar to those machines.

All dangerous moving parts of machines, so located that any person may come in contact with them, should be guarded.

Gears, sprockets, and set screws or similar projections, wherever located, should be guarded if they are not completely encased by the housing of the machine.

All other dangerous moving parts located within six feet of the floor or work platform, if not protected by the housing of the machine, should be guarded unless they are so located with respect to walls, other equipment, or other machines that they are as effectively protected as if they were guarded. Balconies or runways on machines are considered work platforms with respect to the guarding of machine parts near them.

Gears, sprockets, and friction drives should be guarded as is outlined in Section 18, with the additional recommendation that, if a guard or enclosure is within four inches of the moving parts, any openings through the guard which are more than ½ inch in width should be completely covered or should be protected by substantial material such as wire netting with ½ inch or smaller mesh made of wire at least as heavy as No. 20 U. S. Standard Gauge.

Belts and pulleys should be guarded as is outlined in Section 18 or should be completely enclosed. It may not be essential to guard flat belts, which

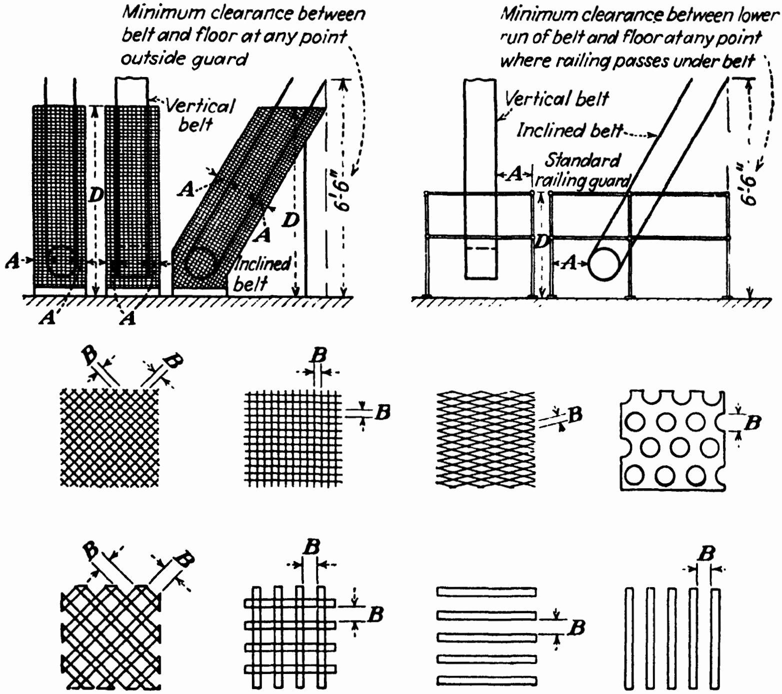


FIG. 1.—Belt guards.

are one inch or less in width or round belts which are ½ inch or less in diameter and which are not driving belts, except in industries in which women are employed and where such belts are so located that hair or clothing is likely to come in contact with them.

Wheels, shafting, spindles, and other revolving or reciprocating parts should be guarded as is outlined in Section 18 or should be completely enclosed. If a guard or enclosure is within four inches of the moving parts, any openings through the guard which are more than ½ inch in width should be completely covered or should be protected by substantial material such as wire netting with ½ inch or similar mesh made of wire at least as heavy as No. 20 U. S. Standard Gauge.

Set screws, bolts, keys, oil cups, and similar revolving projections, which are not enclosed by the housing of the machine, should be made flush, protected with cylindrical safety sleeves, or completely enclosed.

Guards for machine parts should be substantial, adequately supported, and securely fastened. They may well be made in accordance with the general recommendations for the construction of guards which are included in Section 18.

APPENDIX VI

INDUSTRIAL-ACCIDENT STATISTICS*

Accidents Reported to State Industrial Commissions

State	Deaths reported			Cases compensated in 1939			
	1940	1939	Per cent change	Deaths	Non-fatal injuries	Compensation	Medical†
Alabama	112	91	+23				
Arizona	39	.....	....	50	3,065	$ 975,624	$ 322,116
California	760	666	+14				
Colorado	98	105	− 8				
Connecticut	49	50	− 2	72‡	19,596‡	1,637,338‡	1,504,414‡
Florida	106	88	+20	93	10,988§	485,223	629,153
Georgia	94	83	+13	66	7,358	703,914	518,280
Idaho	62	60	+ 3	47	8,079	805,791	225,895
Illinois	465	432	+ 8	445	31,151	6,882,797	‖
Indiana¶	108	100	+ 8	89	19,148	2,368,888	‖
Iowa¶	.....	.....	....	63	3,771	658,916	466,580
Kansas	73	102	−28				
Kentucky¶	.....	.....	....	71	7,387	1,534,851	‖
Maine	32	33	− 3				
Maryland¶	85	95	−11	77	11,082	541,586	545,854
Massachusetts	312	321	− 3	149	22,518	4,523,784	2,615,342
Michigan¶	209	162	+29	189	17,928	3,253,737	‖
Minnesota¶	125	119	+ 5	134	9,691	2,218,815	824,895
Missouri	71	58	+22	79	14,732	1,675,832	892,590
Montana¶	.....	.....	....	70	8,232	1,797,643	314,875
Nebraska	37	58	−36	55	6,331	424,232	276,825
Nevada¶	.....	.....	....	29	2,209	431,819	‖
New Hampshire¶	.....	.....	....	16	2,255	380,575	105,174
New Jersey	297	179	+66	152	21,435	6,031,927	407,745**
New Mexico¶	.....	.....	....	33	2,725	96,345	53,527
New York	1,354	1,344	+ 1	764	76,593	27,971,357	‖
North Carolina¶	138	107	+29	98	9,140	1,112,428	645,669
North Dakota	.....	.....	....	23	3,070	509,923	287,245
Ohio	1,011	997	+ 1				
Oklahoma	.....	.....	....	††	5,503	2,377,520	‖
Oregon	.....	.....	....	105	19,054	3,071,848	1,180,523
Pennsylvania¶	1,280	1,205	+ 6	725	46,188	13,695,799	2,030,807
Rhode Island¶	.....	.....	....	‡‡	4,469	661,755	342,579
South Carolina¶	.....	.....	....	55	8,362	394,223	405,019
Tennessee	107	90	+19				
Texas¶	422	353	+20	338	24,191	7,223,288	2,417,621
Utah¶	.....	.....	....	53	4,062	748,971	353,523
Vermont¶	14	16	−13	14	1,728	205,716	80,058
Virginia	172	158	+ 9	143	9,172	1,167,419	778,279
Washington	225	223	+ 1	248	15,410	3,403,553	1,027,301
West Virginia¶	486	370	+31	395	29,365§§	4,889,279	848,066
Wisconsin	113	127	−11	136	17,606	3,322,424	1,054,944

Source: State labor departments and industrial commissions. Comparisons between states should not be made without consideration of differences in population, industries, and compensation laws.

* "Accident Facts," 1941 Edition, published by the National Safety Council, Inc.

† Includes medical for noncompensable cases wherever obtainable.

‡ Average annual totals for two years ending Nov. 30, 1940, including cases involving medical expense only.

§ Including cases involving medical expense only.

‖ Not available.

¶ Compensated case data for fiscal year.

** For 5,094 cases.

†† No jurisdiction in fatal cases.

‡‡ Included with nonfatal injuries.

§§ Includes cases involving medical expense only.

Compensated Occupational Injuries by Industry and Type of Accident
(Percentages)

Industry	All types	Handling objects	Falls to a different level	Falls to the same level	Machinery	Vehicles	Using hand tools	Falling objects	Stepping on or striking objects	Electricity, explosives, heat	Harmful substances	All others
Average	100	24.2	8.1	10.1	11.0	8.9	7.8	11.6	6.7	3.6	2.6	5.4
All manufacturing	100	24.9	5.3	8.7	21.0	3.6	7.9	9.4	7.2	3.9	3.4	4.7
Slaughtering and meat packing	100	27.0	4.2	12.6	7.8	3.3	20.3	5.2	9.5	2.7	2.0	5.4
Ice	100	30.0	8.2	12.6	5.9	4.0	16.5	8.9	3.2	6.7	0.6	3.4
Other food manufacturing	100	29.3	7.7	12.1	13.1	7.3	4.3	6.8	7.5	5.0	2.8	4.1
Textiles	100	21.2	5.0	10.3	30.8	1.3	8.6	4.6	9.1	2.1	3.3	3.7
Laundries, cleaning, etc.	100	23.4	7.3	11.0	22.0	5.2	3.8	3.4	9.3	6.3	4.6	3.7
Tanning and leather mfg.	100	26.5	4.4	9.6	24.0	1.8	9.2	2.6	9.3	2.1	7.3	3.2
Rubber goods	100	27.0	2.2	3.8	24.2	3.0	12.8	11.2	4.1	4.9	2.2	4.6
Paper, pulp, and paper goods	100	25.7	5.5	9.3	28.9	2.4	4.4	9.0	5.7	2.6	2.2	4.3
Printing and publishing	100	26.6	5.3	9.8	28.9	4.5	2.7	4.7	9.0	2.4	2.7	3.4
Wood products	100	22.1	4.9	5.5	31.9	2.6	8.5	9.9	8.1	1.3	1.2	4.2
Foundries	100	23.7	3.8	4.7	13.3	2.0	8.2	17.8	6.4	5.8	6.5	7.8
Steel works	100	22.9	3.2	6.2	13.0	4.4	9.8	19.2	5.8	4.3	3.4	7.8
Nonferrous metals	100	21.8	3.8	6.3	23.0	4.6	4.6	10.8	7.3	5.7	6.7	5.4
Automobiles	100	21.1	7.6	13.7	16.6	4.0	4.8	11.1	9.7	1.9	2.6	6.9
Machinery	100	25.2	4.6	8.0	30.7	1.7	5.1	7.6	6.9	2.7	3.2	4.3
Other metal products	100	26.3	3.3	6.3	24.1	5.9	9.9	8.6	[illegible]	4.3	2.4	3.5
Clay products	100	28.4	5.2	7.7	6.0	8.3	11.3	17.5	5.4	2.6	3.8	3.8
Glass products	100	21.8	3.5	3.8	7.1	1.9	22.0	24.4	6.1	4.5	2.3	2.6
Chemicals	100	23.8	7.5	9.3	8.9	4.9	6.6	9.7	5.3	9.6	8.9	5.5
Other manufacturing	100	23.1	7.3	6.2	22.7	3.0	8.2	11.2	7.7	3.9	2.7	4.0
Petroleum (production and refining)	100	21.9	3.1	10.3	11.8	6.0	12.1	12.5	4.8	8.6	1.2	7.7
Electric railways	100	26.5	6.4	11.4	2.6	22.9	6.7	4.6	5.4	5.4	1.0	7.1
Other public utilities	100	20.9	8.8	9.3	2.9	18.6	8.6	14.2	6.4	4.3	1.0	5.0
Mining and quarrying	100	14.8	1.3	5.0	4.9	20.8	7.0	34.6	3.7	3.2	0.6	4.1
Construction	100	24.5	16.3	9.1	6.0	4.4	9.4	11.7	7.8	3.3	3.3	4.2
Trucking and cartage	100	35.3	4.4	13.1	1.8	27.9	2.6	3.3	4.4	1.2	0.6	5.3
Logging	100	16.4	2.9	10.3	5.5	4.6	24.0	24.7	6.2	0.7	0.6	4.1
Agriculture	100	22.0	10.9	11.7	6.8	12.0	8.3	3.9	6.5	0.9	3.1	13.9
All other industries	100	25.7	11.6	14.3	5.9	8.3	7.3	5.9	7.5	3.8	2.7	7.0

Source: Reports of nine state labor departments or industrial commissions: Alabama, Illinois, Maryland, Michigan, New Jersey, New York, Pennsylvania, Virginia, and West Virginia. Mostly compensable cases, and for 1938.

TYPES OF OCCUPATIONAL ACCIDENTS, SEVERITY AND COMPENSATION

Type of accident	Percentage of cases				Average compensation per case		
	Total cases	Deaths and permanent totals	Permanent partials	Temporaries	Total cases*	Permanent partials	Temporaries
Total	100.0	100.0	100.0	100.0	$265	$ 609	$ 88
Handling objects	24.3	5.6	20.9	25.3	159	411	79
Falls	18.1	15.9	16.2	18.6	338	897	122
To a different level	8.2	12.1	8.4	8.1	464	1,075	151
To the same level	9.9	3.8	7.8	10.5	231	705	102
Machinery	11.9	9.1	25.0	8.8	332	576	72
Elevators, hoists, conveyors	2.0	5.5	3.9	1.5	526	732	127
Engines, power transmission	0.7	0.5	1.3	0.6	365	714	73
Power-driven machinery	8.7	2.9	18.9	6.3	287	538	59
Other machinery	0.5	0.2	0.9	0.4	243	458	51
Vehicles	8.5	23.1	8.4	8.3	431	798	127
Motor vehicles	4.8	15.0	5.2	4.6	477	861	121
Other vehicles	3.7	8.1	3.2	3.7	376	702	134
Falling objects	10.4	18.1	8.4	10.8	318	605	114
Using hand tools	8.1	1.1	7.8	8.4	136	474	39
Stepping on or striking object	7.5	1.7	4.2	8.3	100	413	48
Electricity, explosives, heat	3.5	13.4	2.5	3.4	458	827	69
Harmful substances	2.7	4.3	1.1	3.3	230	781	83
Animals	0.6	0.3	0.5	0.7	245	863	65
Other types	4.4	7.4	5.0	4.1	$295	$ 528	$ 74

Source: Percentage of cases, reports from eleven state labor departments or industrial commissions; average compensation per case, reports from eight state labor departments or industrial commissions.

* Compensation per case is not shown for deaths and permanent total disabilities because the average compensation ($4,930) is the same for all types of accidents. However, compensation for deaths and permanent total disabilities has been included in the average compensation for all cases.

Types of Occupational Accidents and Nature of Injuries
Percentages

Type of accident	Total	Cuts, lacerations	Bruises, contusions	Strains and sprains	Fractures	Burns and scalds	Amputations	All others
All types	100	29.1	14.6	22.2	17.9	4.5	2.0	9.7
Handling objects	100	23.6	11.6	43.6	13.5	0.1	0.9	6.7
Falls	100	13.3	17.0	36.6	27.1	0.8	0.1	5.1
To a different level	100	12.6	[illegible]	30.5	33.4	0.5	0.1	5.8
To the same level	100	14.0	16.9	41.4	22.0	1.1	0.1	4.5
Machinery	100	47.6	7.9	5.1	21.4	2.1	11.1	4.8
Elevators, hoists, conveyors	100	31.6	13.7	7.2	36.1	0.5	5.8	5.1
Engines, power transmiss	100	31.6	6.6	[illegible]	20.7	10.9	7.6	10.9
Power-driven machinery	100	51.4	5.7	4.5	13.1	1.9	13.7	9.7
Other machinery	100	52.9	10.3	6.1	4.2	3.0	17.8	5.7
Vehicles	100	24.9	17.4	20.0	26.8	0.7	1.4	8.8
Motor vehicles	100	27.7	15.5	18.6	24.3	1.2	0.7	12.0
Other vehicles	100	29.5	16.4	20.6	21.3	0.4	2.1	9.7
Falling objects	100	41.8	16.5	4.2	30.6	0.2	1.0	5.7
Using hand tools	100	60.2	10.5	7.0	10.8	1.0	1.4	9.1
Stepping on, striking object	100	51.7	21.9	3.9	6.4	0.3	0.4	15.4
Electricity, explosives, heat	100	7.1	1.3	0.5	2.6	82.0	0.4	6.1
Harmful substances	100	1.4	0.1	0.2	0.2	47.8	0.1	50.2
All other types	100	28.0	13.7	16.6	16.3	3.3	0.9	21.2

Source: Reports from five State labor departments or industrial commissions: Idaho, Maryland, New York, Pennsylvania, and Wisconsin. Some details partially estimated.

Unsafe Acts and Causes of Permanent Disabilities and Deaths, by Industry

Unsafe act or cause	All industries* Number	All industries* Per cent	Machinery	Steel	Sheet metal	Metal products	Non-ferrous metals	Chemical	Paper and pulp	Food	Public utility	Construction
Unsafe act												
Total cases	2,569	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Unnecessary exposure to danger	681	27	23	27	24	23	33	25	31	29	23	32
Unsafe or improper use of equipment	382	15	20	15	20	13	12	12	17	6	12	11
Working on moving or dangerous equipment	336	13	13	17	13	13	7	17	14	20	11	10
Nonuse personal protective equipment	245	10	8	9	9	8	9	8	6	6	19	8
Improper starting or stopping	219	8	12	8	3	8	8	9	8	5	8	11
Overloading, poor arranging	180	7	6	8	5	4	6	8	10	5	5	9
Making safety devices inoperative	136	5	6	1	9	8	4	4	2	4	10	2
Operating at unsafe speed	72	3	3	2	2	3	3	3	3	5	2	5
No unsafe act	318	12	9	13	15	20	18	14	9	20	10	12
Personal cause												
Total cases	4,202	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Improper attitude	2,055	48	51	46	55	49	43	47	46	52	54	43
Lack of knowledge or skill	1,263	30	33	33	25	27	28	29	35	24	24	33
Bodily defects	98	3	1	2	1	2	2	2	3	2	2	4
No personal cause	786	19	15	19	19	22	27	22	16	22	20	20
Mechanical cause												
Total cases	4,202	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Hazardous arrangement or procedure	1,459	35	33	42	28	27	36	37	40	31	30	40
Improper guarding	1,052	25	21	22	30	25	22	22	28	26	30	19
Defective agencies	667	15	14	14	15	17	20	17	16	16	16	23
Unsafe dress or apparel	247	6	5	5	7	6	8	5	3	6	8	7
Improper illumination, ventilation	30	1	1	1	†	†	†	†	†	1	1	2
No mechanical cause	747	18	26	16	20	25	14	19	13	20	15	9
Number of Accidents:												
Unsafe acts	2,569	....	460	213	152	149	172	179	208	155	376	167
Personal and mechanical causes	4,202	....	681	417	246	264	261	313	360	231	625	223

Source: National Safety Council analysis of reports furnished by individual industrial establishments. Classification of cases was made in accordance with the proposed American Standards Association code for compiling industrial-accident causes. Larger numbers of reports are available for cause information than for unsafe acts merely because the cause data have been collected for a longer period of time.

* Includes information from industries other than the ten for which detailed information is shown.

† Less than half of one per cent.

INDUSTRIAL INJURY RATES BY INDUSTRIES, 1940

Industry	Number of units	Man-hours (thousands)	Frequency rate*						Severity rate*					
			Total injuries		Fatal and permanent total	Permanent partial	Temporary total		Total injuries		Fatal and permanent total	Permanent partial	Temporary total
			Rate	Rank					Rate	Rank			
All industries†	5,163	7,173,924	12.52	..	0.14	0.67	11.71		1.44	..	0.84	0.35	0.25
Automobile	131	553,653	6.92	6	0.04	0.63	6.25		0.78	8	0.24	0.40	0.14
Cement	129	45,690	4.90	2	0.28	0.72	3.90		2.46	26	1.68	0.58	0.20
Chemical	419	325,259	8.65	9	0.17	0.36	8.12		1.33	18	1.02	0.17	0.14
Clay products	74	22,051	19.23	25	0.05	0.54	18.64		0.90	11	0.30	0.29	0.31
Construction	278	384,324	33.47	28	0.44	0.48	32.55		3.58	27	2.64	0.36	0.58
Food	622	269,593	14.04	19	0.05	0.89	13.10		0.95	13	0.30	0.40	0.25
Foundry	117	103,260	19.60	26	0.04	1.10	18.46		1.12	16	0.24	0.50	0.38
Glass	52	98,420	6.60	5	0.09	0.36	6.15		0.86	9	0.54	0.18	0.14
Laundry	22	11,539	5.81	3	0	0	5.81		0.05	1	0	0	0.05
Lumbering	85	50,348	45.50	30	0.48	1.35	43.67		4.80	29	2.88	0.76	1.16
Machinery	316	791,975	9.40	11	0.03	0.81	8.56		0.67	6	0.18	0.31	0.18
Marine	72	319,733	18.34	24	0.13	0.60	17.61		1.51	22	0.78	0.30	0.43
Meat packing	50	98,883	12.77	17	0.05	1.78	10.94		1.05	15	0.30	0.57	0.18
Metal products miscellaneous	186	217,342	12.27	16	0.05	0.77	11.45		0.93	12	0.30	0.41	0.22
Mining	186	87,112	34.24	29	0.92	2.45	30.87		8.41	30	5.52	1.73	1.16
Nonferrous metals	58	159,209	9.83	12	0.08	1.68	8.07		1.40	20	0.48	0.71	0.21
Paper and pulp	246	230,583	15.38	21	0.12	0.89	14.37		1.64	23	0.72	0.61	0.31
Petroleum	170	676,819	11.60	14	0.15	0.50	10.95		1.44	21	0.90	0.29	0.25
Printing and publishing	43	34,297	8.81	10	0.03	0.29	8.49		0.41	3	0.18	0.08	0.15
Public utilities	657	799,741	12.15	15	0.23	0.20	11.72		1.77	25	1.38	0.16	0.23

INDUSTRIAL INJURY RATES BY INDUSTRIES, 1940.—(*Continued*)

Industry	Number of units	Man-hours (thousands)	Frequency rate*					Severity rate*				
			Total injuries		Fatal and permanent total	Permanent partial	Temporary total	Total injuries		Fatal and permanent total	Permanent partial	Temporary total
			Rate	Rank				Rate	Rank			
Quarry	144	13,791	13.20	18	0.51	0.73	11.96	4.08	28	3.06	0.60	0.42
Refrigeration	49	13,460	27.27	27	0.07	0.74	26.46	1.34	19	0.42	0.40	0.52
Rubber	55	133,906	8.27	8	0.02	0.45	7.80	0.65	5	0.12	0.32	0.21
Sheet metal	219	193,131	11.44	13	0.04	1.28	10.12	0.88	10	0.24	0.49	0.15
Steel	130	760,185	6.54	4	0.14	0.92	5.48	1.68	24	0.84	0.59	0.25
Tanning and leather	54	37,201	16.18	22	0	0.27	15.91	0.73	7	0	0.37	0.36
Textile	171	240,209	7.77	7	0.02	0.47	7.28	0.45	4	0.12	0.19	0.14
Tobacco	25	29,955	2.77	1	0	0.23	8.71	0.15	2	0.18	0.09	0.16
Transit	194	322,971	14.24	20	0.12	0.26	13.86	1.23	17	0.72	0.19	0.32
Woodworking	111	46,045	16.40	23	0.02	1.00	15.38	1.04	14	0.12	0.62	0.30

Source: Individual company reports to the National Safety Council. Rankings are indicative rather than exact because of variation from industry to industry in the proportion of companies which maintain accident records and send reports to the National Safety Council. Thus, the information given for cement, petroleum, rubber, steel, and some other industries, is based on the experience of a large proportion of the industry, whereas in tobacco, laundry and some others, the council receives reports from a relatively small proportion of the entire industry. The National Safety Council publishes a separate pamphlet for each industry, giving details of the year's accident experience.

* Frequency rate is the number of disabling injuries per 1,000,000 man-hours of exposure. Severity rate is the number of days lost per 1,000 man-hours of exposure, including charges for permanent disabilities and deaths.

† Includes miscellaneous industries and corrected for certain duplications.

Types of Occupational Accidents, Part of Body Injured, and Average Compensation

Type of accident	Total	Eye	Arm	Hand	Thumb and finger	Leg	Foot	Toe	Other parts and general
All Cases (including deaths and permanent total disabilities)									
Number of cases	232,068	8,982	20,959	19,05[illegible]	50,956	30,723	17,474	11,049	72,874
Average compensation	$274	$328	$[illegible]	$165	$170	$297	$163	$116	$397
Permanent partial disabilities									
Number of cases	49,866	1,693	4,437	2,972	19,702	4,398	2,332	3,222	11,110
Average compensation	$699	$1,596	$1,135	$746	$366	$1,236	$707	$257	$878
All types	100%	100%	100%	100%	100%	100%	100%	100%	100%
Handling objects	21	7	13	20	26	10	22	56	11
Falls	16	1	50	14	5	47	35	3	16
Machinery	25	13	11	25	39	5	8	7	12
Vehicles	8	2	13	8	7	17	11	5	13
Using hand tools	8	28	2	8	10	2	3	5	11
Falling objects	8	14	3	4	4	10	13	20	18
All other types	14	35	8	21	9	9	8	4	19
Temporary disabilities									
Number of cases	179,462	7,278	16,480	15,873	31,401	26,206	15,123	7,823	59,278
Average compensation	$92	$28	$88	$54	$41	$120	$74	$56	$134
All types	100%	100%	100%	100%	100%	100%	100%	100%	100%
Handling objects	25	3	20	20	27	12	20	33	38
Falls	19	1	26	8	2	36	13	3	22
Machinery	9	5	6	10	21	3	3	4	3
Vehicles	8	1	11	6	8	12	10	8	12
Using hand tools	8	10	8	16	19	6	8	7	4
Falling objects	11	53	7	7	9	14	23	39	10
All other types	20	27	22	33	14	17	23	6	11

Source: Reports of seven state labor departments or industrial commissions: Illinois, Maryland, New Jersey, New York, Pennsylvania, West Virginia, and Wisconsin. Some details partially estimated.

DEATHS IN AGRICULTURAL EMPLOYMENT, KANSAS, 1931–1940

Type of accident	Number	Type of accident	Number
Total	904	Excessive heat	94
		In field	70
Machinery	251	Elsewhere	24
Tractor	93		
Circular saw	22	Falls	93
Combine	17	In barn lot or field	19
Disk	10	From barn or loft	18
Plow	9	From vehicle not in motion	15
Corn binder	8	From windmill	11
Hayrake	7	Other	30
Corn cutter	7		
Steam engine	6	Lightning	49
Other	72	At work in barn, barn lot, or field	27
Animals	169	Driving tractor	10
Kicked by horse, mule, cow	66	Hauling wheat or feed	5
Riding horse in work, fell off	36	Other	7
Attacked by bull	34		
Other	33	Miscellaneous	152
		Punctures, cuts, abrasions	39
Vehicular accidents	96	Crushed by falling tree	38
Runaway team and implement or vehicle	75	Burns	31
		Excessive cold	9
Other	21	Other	35

Source: Kansas State Board of Health.

Hours of Danger, Industrial Accidents.—The meager statistics available on the hours of occurrence of industrial accidents show that the most dangerous times of the day occur about three hours after work begins, both in the morning and afternoon.

APPENDIX VII

CAUSES OF COMPENSATED ACCIDENTS[1]

GENERAL NOTE

The data included in Part I of this report refer to all industrial injuries, regardless of compensability, which resulted in disability of at least one day or shift. They refer to the number of injuries *reported* during the year, which varies slightly from the number that actually occurred during the same period.

In both parts of this supplement readers may find small discrepancies among the total figures. This is due to several reasons: in the first place, some of the tables were summarized from the monthly reports and in other cases were prepared by machine tabulation. The tabulated tables of course, contain all the revisions and corrections that occurred during the twelve-month period.

The statistical tables presented here are based on a modification of the Heinrich Cause Code, adopted in Pennsylvania in January, 1938. The tables were patterned generally on those suggested in the U. S. Bureau of Labor Statistics' *Bull.* 667, "Manual on Industrial Injury Statistics."

Additional copies of this supplement may be received free of charge by addressing a request to Margaret M. Memmert, Director, Bureau of Research and Information 507 Feller Building, Harrisburg, Pa.

[1] Excerpts from 1939 Statistical Supplement of Industrial Injuries in Pennsylvania. Prepared by the Bureau of Research and Information, Margaret M. Memmert, Director.

TABLE 1.—INDUSTRIAL INJURIES IN PENNSYLVANIA INDUS

Industry	All injuries			Object causing injury							
								Vehicles			
	Number	Per cent of total	Per cent change 1938–1939	Machines	Pumps and prime movers	Elevators, hoisting apparatus, conveyors	Boilers (pipe and pressure apparatus)	All vehicles	Motor vehicles	Railway and mine and quarry vehicles	Other vehicles
All industries	103,607	100.0	+ 4.2	9361	429	2253	206	13409	5796	5381	2232
Percentage of all agencies	....	100.0	....	9.0	0.4	2.2	0.2	13.0	5.6	5.2	2.2
Percentage change from 1938	+4.2	....	....	+13.3	+0.7	+1.3	−29.5	+1.9	+1.9	−0.9	+9.1
Manufacturing Industries											
Total	35,246	34 0	+ 11.7	6944	100	935	83	3382	1740	373	1269
Iron and steel and their products	9,983	9.6	+ 12.8	1960	33	457	27	454	98	89	267
Nonferrous metal products	1,650	1.6	+167.4	311	3	45	3	115	21	12	82
Transportation equipment	3,490	3.4	+ 10 6	304	12	99	2	928	737	137	54
Textiles and clothing	4,427	4.3	+ 12 0	1759	7	33	6	177	54	6	117
Food products	5,804	5.6	+ 0 2	438	14	153	21	841	555	25	261
Stone, clay, and glass products	2,104	2.0	+ 28 3	185	11	36	3	255	31	50	174
Lumber products	1,929	1.9	− 0.1	510	5	11	......	99	40	3	56
Chemical and allied products	1,357	1.3	− 3 2	75	7	44	13	168	95	26	47
Leather and its products	1,336	1.3	+ 12.3	405	1	14	4	88	10	4	74
Paper and printing	2,162	2.1	+ 0.7	671	4	30	4	194	76	12	106
Other manufacturing	1,004	0.9	+ 13.4	326	3	13	......	63	23	9	31
Nonmanufacturing Industries											
Total	68,361	66.0	+ 0 8	2417	329	1318	123	10027	4056	5008	963
Anthracite mining	13,240	12.8	− 0.6	200	24	303	9	1612	76	1520	16
Bituminous coal mining	9,456	9.1	− 3.7	481	9	250	......	2427	18	2392	17
Quarrying and nonmetallic mining	869	0.8	+ 18.4	35	7	41	3	104	46	49	9
Retail trade	8,934	8.6	− 5.4	449	26	114	12	1151	948	43	160
Wholesale trade	2,763	2.7	+ 3.6	74	7	65	7	517	376	30	111
Crude petroleum producing	790	0 8	− 8.7	84	78	19	......	41	31	.....	10
Construction and contracting	11,148	10.8	+ 11.9	365	111	305	30	709	463	73	173
Transportation and communication	2,465	2.4	+ 23.6	28	2	17	......	844	590	129	125
Light, heat, and power	829	0 8	+ 3.6	18	13	14	5	56	39	5	12
Laundry and dyeing and cleaning	527	0.5	− 12.8	112	.....	7	3	76	58	1	17
Hotels and restaurants	2,877	2.8	− 7.3	127	3	23	8	38	30	.....	8
Steam railroads	1,667	1.6	− 4.5	9	2	24	2	776	28	690	58
State and municipal	5,924	5.7	+ 2.0	157	22	26	17	954	811	35	108
Other nonmanufacturing	6,872	6.6	− 1.4	278	25	110	27	722	542	41	139

* This tabulation includes all injuries reported during the year to the Bureau of Workmen's Compensation
abling injuries causing disability for one day or more.

TRIES CLASSIFIED BY OBJECT CAUSING INJURY: YEAR 1939*

Object causing injury														
		Hand tools			Chemicals									
Mechanical power-transmission apparatus	Electrical apparatus	All hand tools	Hand tools (no mechanical power)	Hand tools (mechanically power driven)	All chemicals	Explosives and explosive gases and vapors	Highly inflammable substances (including inflammable dusts)	[illegible] vapors, gases, fumes, and dusts	Hot and corrosive substances	Other chemical substances	Working surfaces	Other objects	Object unclassified
143	530	9943	8617	1326	4106	512	348	440	2626	180	5683	56686	858
0.1	0.5	3.6	8.3	1.3	4.0	0.5	0.3	0.4	2.6	0.2	5.5	54.7	0.8
−62.8	−15.6	−1.0	−2.8	+12.2	+9.5	−6.4	+3.3	+23.6	+25.0	−56.1	−17.3	+7.0	+115.8
Manufacturing Industries														
67	144	3405	2879	526	1719	108	139	121	1264	87	1548	16598	321
21	36	924	720	204	633	34	21	31	532	15	280	5087	71
4	21	129	105	24	119	6	7	21	79	6	57	825	18
4	23	583	422	161	180	10	46	13	105	6	95	1236	24
11	14	479	421	58	96	2	2	3	79	10	266	1530	49
7	13	407	389	18	267	12	8	22	207	18	461	3135	47
3	9	150	133	17	102	6	9	7	79	1	78	1246	26
4	......	288	279	9	18	1	7	2	8	......	49	933	12
2	5	115	102	13	166	25	24	14	89	14	61	686	15
2	4	140	132	8	40	2	6	1	26	5	52	569	17
8	15	109	102	7	61	1	7	7	38	8	105	934	27
1	4	81	74	7	37	9	2	......	22	4	44	417	15
Nonmanufacturing Industries														
76	386	6538	5738	800	2387	404	209	319	1362	93	4135	40088	537
33	104	1054	872	182	233	134	4	31	61	3	587	9052	29
8	70	984	904	80	83	43	1	5	30	4	272	4849	23
2	3	83	65	18	34	6	6	2	20	......	39	511	7
6	34	996	948	48	238	25	43	26	129	15	640	5151	117
2	9	153	140	13	40	2	7	9	20	2	151	1701	37
4	......	120	115	5	46	20	10	3	11	2	52	334	12
13	35	1295	1062	233	531	34	58	25	405	9	520	7128	106
3	22	130	107	23	59	9	19	10	20	1	133	1217	10
.....	37	126	107	19	42	15	3	6	14	4	64	449	5
....	2	45	38	7	37	2	2	3	25	5	48	193	4
....	6	364	360	4	392	42	.....	2	331	17	331	1535	50
1	8	124	107	17	31	8	1	3	19	......	91	592	7
1	19	538	420	118	335	29	22	172	101	11	558	3245	52
3	37	526	493	33	286	35	33	22	176	20	649	4131	78

of the Department of Labor and Industry under the Pennsylvania law which requires the reporting of dis-

TABLE 2.—FATAL INDUSTRIAL INJURIES IN PENNSYLVANIA IN

Industry	All injuries			Object causing injury							
								Vehicles			
	Number	Per cent of total	Per cent change 1938–1939	Machines	Pumps and prime movers	Elevators, hoisting apparatus, conveyors	Boilers (pipe and pressure apparatus)	All vehicles	Motor vehicles	Railway and mine and quarry vehicles	Other vehicles
All industries	1,204	100 0	+ 9.5	42	4	50	3	296	133	150	13
Manufacturing Industries											
Total	250	20.7	+ 11.6	25	1	22	2	40	24	11	5
Iron and steel and their products	95	7.8	+ 31.9	12	..	13	1	11	3	7	1
Nonferrous metal products	10	0.9	0.0	..	..	.	1	2	. .	...	2
Transportation equipment	29	2.4	+ 7.4	3	..	1	..	6	3	2	1
Textiles and clothing	19	1.6	0.0	5	1	1	..	2	2	...	..
Food products	34	2.8	− 2.9	..	..	3	..	14	12	1	1
Stone, clay, and glass products	10	0.8	− 28.6	3	..	1	..	1	...	1	..
Lumber products	10	0.8	− 16.7	2	..	..	..	...	...	...	..
Chemicals and allied products	26	2.2	+160.0	..	..	2	..	3	3	...	..
Leather and its products	2	0.2	− 66.7	..	..	..	..	.	...	...	..
Paper and printing	9	0.7	− 47.1	..	..	1		1	1	...	..
Other manufacturing	6	0.5	+200.0	..	..	..	.	...	.	...	..
Nonmanufacturing Industries											
Total	954	79.3	+ 8.9	17	3	28	1	256	109	139	8
Anthracite mining	254	21.1	+ 2.8	1	.	11	.	37	3	34	
Bituminous coal mining	169	14.1	− 2.3	5	1	1	..	42	1	41	..
Quarrying and nonmetallic mining	10	0.8	+ 25.0	..	..	1	..	1	...	1	..
Retail trade	50	4.2	+ 16.3	..	..	3	..	19	15	3	1
Wholesale trade	20	1.6	− 9.1	1	..	1	..	8	8	...	..
Crude petroleum producing	10	0.9	+ 42.9	1	1	..	..	...	...	...	..
Construction and contracting	109	9.0	0.0	4	..	6	..	19	16	2	1
Transportation and communication	46	3.8	+142.1	..	..	..	..	25	15	9	1
Light, heat, and power	20	1.7	+ 11.1	..	1	..	..	1	1	...	..
Laundry and dyeing and cleaning	3	0.2	0.0	..	..	..	..	2	1	1	..
Hotels and restaurants	13	1.1	+ 8.3	..	..	1	..	...	...	...	.
Steam railroads	60	5.0	− 3.2	1	..	1	..	45	1	43	1
State and municipal	112	9.3	+ 28.7	..	..	..	1	35	31	3	1
Other nonmanufacturing	78	6.5	+ 18.2	4	..	3	..	22	17	2	3

* This tabulation includes all injuries reported during the year to the Bureau of Workmen's Compensation abling injuries causing disability for one day or more.

DUSTRIES CLASSIFIED BY OBJECT CAUSING INJURY: YEAR 1939*

Object causing injury													
		Hand tools			Chemicals								
Mechanical power-transmission apparatus	Electrical apparatus	All hand tools	Hand tools (no mechanical power)	Hand tools (mechanically power driven)	All chemicals	Explosives and explosive gases and vapors	Highly inflammable substances (including inflammable dusts)	Noxious vapors, gases, fumes, and dusts	Hot and corrosive substances	Other chemical substances	Working surfaces	Other objects	Object unclassified
1	42	29	21	8	100	48	16	19	15	2	40	573	24
Manufacturing Industries													
..	10	12	7	5	30	10	8	1	10	1	15	87	6
..	4	7	3	4	7	2	.	..	5		3	35	2
..	3	..	.	..	...	..	.	..	..		..	4	
..	1	3	2	1	2	..	1	.		1	4	9	
..	.	.	.	..	1	..	..		1	.	2	6	1
..	.	.	..	..	1	.	..	1	..		2	12	2
	..	.	..	..	...	.	..	..	..	.	..	4	1
..	.	1	1	..	...	.	..	..	.		..	7	
	1	1	1	..	15	7	5	..	3	..	.	4	
..	1		..	..	.	..	..	..	..	..	1		
..	..	.	.	..	2	..	2	..	..	.	1	4	
..		.			2	1	..	.	1	.	2	2	
Nonmanufacturing Industries													
1	32	17	14	3	70	38	8	18	5	1	25	486	18
	4	3	3		21	16	1	2	2	.	7	167	3
	5	1		1	3	2	.	1	.	.	1	107	3
	1	.	..	.	..	.	..		.	.	..	7	
..	1	3	3	..	6	2	2	2	..	..	4	10	4
.	..	1	1	..	2	..	..	2	..	..	1	6	
.	..	1	1	.	...	..	..	..	..	..	..	7	
..	8	2	1	1	5	3	..	1	1	..	3	60	2
1	..	..	..	..	6	1	1	4	..	.	1	12	1
	10	.	..	..	2	1	1	..	.	.	..	5	1
	.		.	..	...	.	..	.	.	.	..	1	
..	.	1	1	..	2	1	..	..	1	..	1	7	1
.	1			..	1	1	..	..	..	..	..	10	1
.	1	4	3	1	12	5	1	5	1	..	4	53	2
.	1	1	1	.	10	6	2	1	..	1	3	34	

of the Department of Labor and Industry under the Pennsylvania law which requires the reporting of dis-

TABLE 3.—CAUSES OF INDUSTRIAL ACCIDENTS

Cause of accident	All injuries: Number	All injuries: Per cent of total	All injuries: Per cent change 1938–1939	Object causing injury: Machines	Object causing injury: Pumps and prime movers	Object causing injury: Elevators, hoisting apparatus, conveyors	Object causing injury: Boilers (pipe and pressure apparatus)	Vehicles: All vehicles	Vehicles: Motor vehicles
Unsafe acts									
All accidents	103,607	100.0	+ 4.2	9361	429	2,253	206	13,409	5,796
Unsafe acts—total	99,264	95.8	+ 5.3	9254	422	2,221	204	13,151	5,646
Operating equipment without authority or proper clearance	877	0.8	−15.0	203	8	63	...	474	132
Operating or working at unsafe speed	3,883	3.7	−49.2	51	...	15	1	695	492
Making safety devices inoperative	95	0.1	−62.2	68	...	4	...	1	.....
Using defective or unsafe tools or equipment, or using tools or equipment unsafely	15,321	14.8	+34.2	2046	148	586	72	1,890	929
Overloading, crowding, poor arranging	43,905	42 4	+52.6	3174	91	743	59	4,500	1,653
Unnecessary exposure to danger	27,556	26.6	−14.8	2379	144	700	56	5,181	2,325
Working on moving or dangerous equipment	1,862	1.8	−13.8	800	30	88	15	325	77
Distracting attention, teasing, abusing, etc	592	0.6	+ 8.2	14	..	3	..	19	6
Failure to use safety devices	4,849	4.7	−18.0	514	1	19	1	50	21
Other unsafe acts	324	0.3	−92.3	5	...	....	...	16	11
No unsafe act	2,941	2.8	+ 6.6	69	2	19	..	170	89
Unclassified—insufficient data	1,402	1.4	−41.5	38	5	13	2	88	61
Mechanical or material causes									
All accidents	103,607	100.0	+ 4.2	9361	429	2,253	206	13,409	5,796
Mechanical or material causes—total	99,093	95.6	+ 7.5	9210	418	2,220	201	13,110	5,604
Improperly guarded agencies	857	0.8	− 3.9	588	4	28	...	12	4
Defective agencies	27,246	26.3	+ 6 3	2330	126	591	65	2,744	1,416
Hazardous arrangement, procedure, etc	65,520	63.2	+12.3	5768	287	1,576	134	10,272	4,146
Improper illumination	178	0.2	−38.0	3	...	4	...	22	9
Improper ventilation	316	0.3	+21.5	3	...	.....	...	2	2
Unsafe dress or apparel	4,872	4.7	−17.2	517	1	20	1	49	21
Other mechanical or material causes	104	0.1	−88.7	1	...	1	1	9	6
No mechanical or material cause	1,730	1.7	−35.0	19	...	1	...	31	24
Unclassified—insufficient data	2,784	2.7	−38.3	132	11	32	5	268	168

* This tabulation includes all injuries reported during the year to the Bureau of Workmen's Compensation injuries causing disability for one day or more.

Classified by Object Causing Injury: Year 1939*

Object causing injury																
Vehicles			Mechanical power-transmission apparatus	Electrical apparatus	Hand tools			Chemicals						Working surfaces	Other objects	Object unclassified
Railway vehicles	Mine and quarry vehicles	Other vehicles			All hand tools	Hand tools (no mechanical power)	Hand tools (mechanically power driven)	All chemicals	Explosives and explosive gases and vapors	Highly inflammable substances (including inflammable dusts)	Noxious vapors, gases, fumes, and dusts	Hot and corrosive substances	Other chemical substances			
Unsafe acts																
1,402	3,979	2,232	143	530	9,943	8,617	1,326	4,106	512	348	440	2626	180	5683	56,686	858
1,355	3,942	2,208	143	524	9,841	8,528	1,313	3,871	501	337	415	2464	154	5123	54,395	115
42	255	45	1	6	12	2	10	17	6	1	...	9	1	....	93	
51	87	65	3	4	64	43	21	19	1	...	1	15	2	1425	1,604	2
. .	.....	1	1	1	4	.....	4	4	...	...	...	4	...	2	10	
264	437	260	24	202	4,672	4,280	392	504	121	44	26	289	24	377	4,796	4
440	1,281	1,126	31	110	1,906	1,644	262	1,729	139	185	50	1313	42	3065	28,454	43
496	1,687	673	52	71	2,701	2,372	329	663	128	53	224	229	29	185	15,359	65
50	180	18	23	106	28	9	19	235	81	48	8	98	...	7	205	
1	1	11	1	...	23	20	3	24	21	...	1	2	...	1	507	
9	14	6	7	22	427	156	271	650	2	4	95	501	48	61	3,096	
2	....	3	. .	2	4	2	2	26	2	2	10	4	8	....	271	
36	26	19	...	1	89	79	10	219	5	6	25	159	24	476	1,881	15
11	11	5	...	5	13	10	3	16	6	5	...	3	2	84	410	728
Mechanical or material causes																
1,402	3,979	2,232	143	530	9,943	8,617	1,326	4,106	512	348	440	2626	180	5683	56,686	858
1,373	3,936	2,197	143	522	9,800	8,487	1,313	3,865	496	336	413	2471	149	5419	54,062	123
5	1	2	7	3	6	1	5	4	...	...	...	4	...	40	165	
338	677	313	46	179	4,144	3,903	241	264	33	23	23	175	10	3453	13,274	30
1,022	3,240	1,864	81	313	5,210	4,419	791	2,641	401	300	77	1779	84	1839	37,309	90
.....	4	9	1	3	5	4	1	8	7	...	...	1	...	24	107	1
.....	.....	.....	...	...	.....	.....	.....	279	52	9	212	5	1	3	29	
8	14	6	8	22	432	158	274	652	3	4	93	503	49	60	3,108	2
.....	.....	3	...	2	3	2	1	17	...	...	8	4	5	....	70	
3	.....	4	...	1	73	66	7	208	6	6	24	146	26	44	1,346	7
26	43	31	...	7	70	64	6	33	10	6	3	9	5	220	1,278	728

of the Department of Labor and Industry under the Pennsylvania law which requires the reporting of disabling

TABLE 4.—KIND OF ACCIDENT AND NATURE OF INJURY,

Kind of accident and nature of injury	All injuries			Object causing injury					
	Number	Per cent of total	Per cent change 1938–1939	Machines	Pumps and prime movers	Elevators, hoisting apparatus, conveyors	Boilers (pipe and pressure apparatus)	Vehicles: All vehicles	Vehicles: Motor vehicles
Kind of accident									
All accidents	103,607	100.0	+ 4.2	9361	429	2,253	206	13,409	5796
Striking against	18,683	18.0	+ 4.2	2416	38	238	36	2,561	1455
Struck by	35,352	34.2	− 0.5	2444	196	790	58	3,380	1847
Caught in or between	12,675	12.2	+20.7	3615	90	846	22	3,218	803
Falls—on same level	6,378	6.2	+ 0.5	59	10	50	3	463	175
Falls—to different level	6,654	6.4	+ 0.4	102	7	138	7	1,309	702
Slips (not falls) and overexertion	16,655	16.1	+ 1.5	503	71	170	22	2,210	659
Burning and scalding	4,075	3.9	+17.0	149	9	7	55	112	73
Inhalation, absorption, or swallowing	1,239	1.2	−10.9	5	..	.....	...	7	7
Other kinds of accidents	741	0 7	+34 5	34	6	8	2	95	41
Kind of accident unclassified	1,155	1 1	+81.8	34	2	6	1	54	34
Nature of injury									
All accidents	103,607	100 0	+ 4.2	9361	429	2,253	206	13,409	5796
Amputation	1,629	1.6	+24.9	865	21	104	2	198	45
Asphyxiation	212	0.2	−41.3	2	...	. ..	...	7	7
Burns and scalds	4,508	4.4	+12.7	199	13	15	61	127	73
Concussion	430	0.4	+ 9.7	11	1	20	1	142	106
Cuts, lacerations, punctures, and bruises	49,867	48.1	+ 3.6	5625	174	1162	71	5,991	2473
Drowning	2	†	−83.3	....	...	.....	...	......	..
Fractures	13,517	13.1	+10.5	1205	87	553	27	2,508	1118
Hernia	2,324	2.2	− 9.6	83	16	27	2	326	104
Infection	6,345	6.1	− 1.7	496	16	54	9	385	232
Sprains, strains, and dislocations	19,728	19.0	+ 9.2	637	69	242	22	2,944	1115
Nature of injury unclassified	5,045	4.9	−13.7	238	32	76	11	781	523

* This tabulation includes all injuries reported during the year to the Bureau of Workmen's Compensation abling injuries causing disability for one day or more.

† Less than 0.05 per cent.

Classified by Object Causing Injury: Year 1939*

Object causing injury

Vehicles: Railway vehicles	Vehicles: Mine and quarry vehicles	Vehicles: Other vehicles	Mechanical power-transmission apparatus	Electrical apparatus	Hand tools: All hand tools	Hand tools: Hand tools (no mechanical power)	Hand tools: Hand tools (mechanically power driven)	Chemicals: All chemicals	Chemicals: Explosives and explosive gases and vapors	Chemicals: Highly inflammable substances (including inflammable dusts)	Chemicals: Noxious vapors, gases, fumes, and dusts	Chemicals: Hot and corrosive substances	Chemicals: Other chemical substances	Working surfaces	Other objects	Object unclassified
Kind of accident																
1402	3979	2232	143	530	9943	8617	1326	4106	512	348	440	2626	180	5683	56,686	858
280	505	321	24	54	1422	1314	108	49	3	...	..	39	7	627	11,165	53
316	562	655	42	53	5879	5314	565	679	184	12	20	409	54	17	21,791	23
238	1729	448	51	31	504	404	100	5	1	1	...	3	...	10	4,273	10
80	80	128	6	16	245	198	47	11	...	1	2	8	...	3125	2,380	10
334	105	168	3	17	58	43	15	8	5	...	2	1	...	410	4,592	3
131	948	472	16	38	1410	1240	170	7	...	...	...	7	...	1460	10,683	65
6	31	2	1	303	290	10	280	2771	295	317	41	2066	52	6	369	3
....	....	....	...	3	10	7	3	569	21	16	373	92	67	....	635	10
12	11	31	...	10	113	79	34	3	1	...	2	....	...	21	438	11
5	8	7	...	5	12	8	4	4	2	1	...	1	...	7	360	670
Nature of injury																
1402	3979	2232	143	530	9943	8617	1326	4106	512	348	440	2626	180	5683	56,686	858
46	83	24	4	5	119	104	15	6	4	...	..	2	...	1	301	3
....	....	....	...	4	...	...	...	151	11	1	139	....	...	...	48	
14	36	4	1	301	299	17	282	3027	292	314	51	2296	74	18	440	7
22	8	6	1	...	19	16	3	3	2	...	1	....	...	19	213	
550	1989	979	79	88	5982	5399	583	217	122	11	6	61	17	1591	28,673	214
....	....	....	...	...	....	....	....	....	...	...	...	....	...	....	2	
393	653	344	24	32	727	618	109	48	38	...	3	7	...	964	7,306	36
20	117	85	2	9	192	175	17	....	...	...	...	....	...	89	1,515	63
23	42	88	9	8	906	857	49	342	4	12	24	231	71	167	3,756	197
278	976	575	19	41	1455	1256	199	4	2	1	...	1	...	2326	11,860	109
56	75	127	4	42	244	175	69	308	37	9	216	18	18	508	2,572	229

of the Department of Labor and Industry under the Pennsylvania law which requires the reporting of dis-

TABLE 5.—CAUSES OF INDUSTRIAL ACCIDENTS CLASSIFIED BY KIND OF ACCIDENT: YEAR 1939*

Cause of accident	All accidents	Kind of accident: Striking against	Struck by	Caught in or between	Falls—on same level	Falls—to different level	Slips (not falls) and over-exertion	Burning and scalding	Inhalation, absorption, or swallowing	Other kinds of accidents	Kind of accident unclassified
Unsafe acts											
All accidents	103,607	18,683	35,352	12,675	6,378	6,654	16,655	4,075	1,239	741	1,155
Unsafe acts—total	99,264	18,052	34,819	12,615	5,851	6,296	16,411	3,931	588	625	76
Operating equipment without authority or proper clearance	877	42	241	518	8	36	11	17	.....	3	1
Operating or working at unsafe speed	3,883	726	344	110	1,360	424	894	13	1	7	4
Making safety devices inoperative	95	16	20	32	1	9	......	7			
Using defective or unsafe tools or equipment, or using tools or equipment unsafely	15,321	3,178	7,231	1,508	624	1,422	453	696	42	148	19
Overloading, crowding, poor arranging	43,905	10,298	16,741	5,398	3,343	3,442	2,658	1,876	93	41	15
Unnecessary exposure to danger	27,556	2,973	6,024	3,929	431	827	12,339	402	271	342	18
Working on moving or dangerous equipment	1,862	156	332	930	26	65	24	313	3	6	7
Distracting attention, teasing, abusing, etc	592	49	386	89	26	14	15	4	.....	6	3
Failure to use safety devices	4,849	587	3,294	101	20	49	13	596	140	46	3
Other unsafe acts	324	17	206	......	12	8	4	7	38	26	6
No unsafe act	2,941	554	436	39	432	286	208	125	637	86	138
Unclassified—insufficient data	1,402	77	97	21	95	72	36	19	14	30	941
Mechanical or material causes											
All accidents	103,607	18,683	35,352	12,675	6,378	6,654	16,655	4,075	1,239	741	1,155
Mechanical or material causes—total	99,093	17,795	34,717	12,632	6,006	6,355	16,406	3,938	577	592	75
Improperly guarded agencies	857	230	170	275	1	166	5	7	.....	3	
Defective agencies	27,246	9,973	6,964	1,731	3,420	2,250	2,251	567	35	36	19
Hazardous arrangement, procedure, etc	65,520	6,941	24,231	10,518	2,514	3,833	14,119	2,700	130	487	47
Improper illumination	178	49	5	5	44	46	17	9	.....	2	1
Improper ventilation	316	1	8	......	5	6	1	54	238	2	1
Unsafe dress or apparel	4,872	592	3,304	103	20	51	12	597	142	47	4
Other mechanical or material causes	104	9	35	......	2	3	1	4	32	15	3
No mechanical or material cause	1,730	150	446	5	61	28	64	113	637	89	137
Unclassified—insufficient data	2,784	738	189	38	311	271	185	24	25	60	943

* This tabulation includes all injuries reported during the year to the Bureau of Workmen's Compensation of the Department of Labor and Industry under the Pennsylvania law which requires the reporting of disabling injuries causing disability for one day or more.

TABLE 8.—INDUSTRIAL INJURIES RESULTING IN DISABILITY OF ONE DAY OR MORE, BY MANUFACTURING INDUSTRY GROUP AND UNSAFE ACT—YEAR 1939

Unsafe acts	Total manufacturing industries	Iron and steel	Non-ferrous metals	Transportation equipment	Textile and clothing	Food products	Stone, clay, and glass	Lumber products	Chemicals and allied products	Leather and its products	Paper and printing	Other manufacturing
Total—Manufacturing	35,268	9,852	1,686	3,601	4,429	5,806	2,104	1,925	1,357	1,347	2,163	998
Fatal	250	96	10	28	17	34	10	12	26	2	9	6
Nonfatal	35,018	9,756	1,676	3,573	4,412	5,772	2,094	1,913	1,331	1,345	2,154	992
Operating equipment without authority or proper clearance												
Starting, stopping, using, operating, firing, moving, etc.—without authority	(1) 11	2	1	2	....	(1) 2	1	....	1	1	1	
Without giving proper signal	25	9	1	4	1	5	1	2	....	....	2	
Failing to tag, lock, block, or secure vehicles, switchs, valves, press rams, and other tools, materials and equipment against unexpected motion, flow of electric current, steam, etc	(5) 206	(4) 62	6	29	28	(1) 32	12	2	3	6	22	4
Failing to shut off equipment not in use	3	1	..	1	....	....	....	....	....	....	....	1
Releasing or moving loads, etc., without giving warning	(1) 5	(1) 2				1	1	....				1
N.O.C.*	(2) 71	24	(1) 1	12	(1) 11	7	4	1	3	3	3	2
Operating or working at unsafe speed												
Running	63	11	1	7	11	24	3	....	2	....	3	1
Feeding or supplying too rapidly	11	3	2			....		3	1	1	1	
Driving too rapidly	(6) 75	(1) 3	1	(1) 10	5	(4) 35	4	.	6	1	5	5
Throwing material instead of carrying or passing it	46	15	....		4	14	6	2	..	....	4	1
Jumping from vehicles, platforms, etc	(2) 108	19	2	(1) 9	(1) 15	33	6	6	10	1	5	2
N.O.C	(4) 742	100	25	(1) 39	(1) 122	(1) 256	28	22	43	30	56	(1) 21
Making safety devices inoperative												
Removing safety devices	(4) 24	(2) 6	3	1	4	1	(1) 3	(1) 2	1	....	3	
Making safety devices inoperative	7	4	1	1	1							
Misadjusting safety devices	9	2	1	2	....	....	....	2	.	....	....	2
N.O.C.*	(1) 28	(1) 5	1	2	7	2	1	3	1	....	4	2

NOTE: Figures in parentheses refer to fatal cases which are not included in accompanying figures.

* Not otherwise classified.

TABLE 8A.—INDUSTRIAL INJURIES RESULTING IN DISABILITY OF ONE DAY OR MORE, BY MANUFACTURING INDUSTRY GROUP AND UNSAFE ACT—YEAR 1939

Unsafe acts	Total manufacturing industries	Iron and steel	Non-ferrous metals	Transportation equipment	Textile and clothing	Food products	Stone, clay, and glass	Lumber products	Chemicals and allied products	Leather and its products	Paper and printing	Other manufacturing
Using defective or unsafe tools or equipment, or using good tools or equipment unsafely												
Using defective tools and equipment (mushroom head chisels, etc.)	(24) 1,663	(14) 441	(1) 74	(3) 232	186	(3) 345	107	58	(1) 74	(1) 48	(1) 66	32
Unsafe use of tools and equipment (*cf.* iron bars for tamping explosives, operating pressure valves at unsafe pressures, volume, etc.)	6	1	......	......	......	3	......	......	......	1	1	
Using hands instead of hand tools (to feed, clean, adjust, repair, etc.)	155	69	11	17	9	19	4	5	4	4	8	5
N.O.C.*	(11) 4,054	(8) 1,061	(1) 167	524	(1) 603	526	174	304	(1) 131	218	220	126
Overloading, crowding, poor arranging												
Overloading	29	12	1	2	1	5	4	2	......	......	1	1
Crowding	98	29	3	4	17	22	3	4	2	8	5	1
Using beyond capacity	5	2	......	......	......	......	2	1				
Lifting or carrying loads too heavy for one person	74	30	6	6	8	12	1	1	4	2	4	
Arranging or placing objects or materials unsafely (parking, placing, stopping, or leaving vehicles, elevators, and conveying apparatus in unsafe position for loading or unloading)	(2) 1,462	(1) 539	67	166	124	200	87	(1) 68	52	39	89	31
Injecting, mixing, or combining one substance with another so that explosion, fire, or other hazard is created (injecting cold water into hot boiler, pouring water into acid, etc.)	(3) 56	(1) 22	7	10	1	5	3	1	(2) 7			
Introducing objects or materials unsafely (Portable electric lights inside of boilers of in spaces containing inflammables or explosives; moving euqipment in congested workplaces, smoking where explosives or inflammables are kept, etc.)	(1) 38	(1) 7	3	12	1	4	4	1	3	1	1	1
Failure to guard against falling or sliding objects	(5) 730	(2) 226	31	63	25	94	87	(2) 115	35	10	(1) 39	5
N.O.C.*	(39) 11,287	(17) 2,954	533	(7) 1,108	(3) 1,603	(3) 1,947	(2) 660	(2) 617	396	(1) 418	(3) 716	(1) 335

NOTE: Figures in parentheses refer to fatal cases which are not included in accompanying figures.
* Not otherwise classified.

TABLE 8B.—INDUSTRIAL INJURIES RESULTING IN DISABILITY OF ONE DAY OR MORE, BY MANUFACTURING INDUSTRY GROUP AND UNSAFE ACT—YEAR 1939

Unsafe acts	Total manufacturing industries	Iron and steel	Nonferrous metals	Transportation equipment	Textile and clothing	Food products	Stone, clay, and glass	Lumber products	Chemicals and allied products	Leather and its products	Paper and printing	Other manufacturing
Unnecessary exposure to danger												
Exposure under suspended loads	(1) 124	86	4	(1) 12	1	8	3	....	4	1	4	1
Exposure on vehicular right of way	(3) 38	(1) 7	4	2	2	(1) 11	2	....	1	...	(1) 8	1
Putting body or its parts into shaftways or openings—standing too close to openings	(2) 29	(1) 5	2	(1) 2	8	5	3	1	....	...	2	1
Entering vessel or enclosure when unsafe because of temperature, gases, electric, or other exposures	(2) 76	27	(1) 13	(1) 7	2	7	3	4	6	2	3	2
Gripping objects insecurely; taking wrong hold of objects, lifting with bent back, while in awkward position, etc.	(22) 8,041	(4) 2,246	(3) 403	(6) 707	(1) 1,023	(3) 1,255	(1) [illegible]	441	(3) 293	366	493	(1) 244
Riding in unsafe position (on platforms, tailboards, and running boards of vehicles; ta ling on or stealing rides; riding on apparatus designed only for materials, etc.)	(3) 46	(2) 13	....	5	(1) 2	14	6	3	1	...	2	
Passing on grades and curves, cutting in and out, violating traffic signals, road hogging	(4) 190	16	4	19	6	(2) 97	2	7	(2) 8	1	24	6
N.O.C.*	(28) 1,266	(12) 370	62	(5) 133	(1) 124	(3) 210	(3) 82	(2) 60	(2) 60	38	92	35
Working on moving or dangerous equipment												
Getting on or off equipment that is in motion (vehicles, conveyors, elevators, animals, etc.)	18	4	1	....	1	10	2					
Working on equipment that is in motion (cleaning, oiling, adjusting, etc.)	(6) 700	(4) 129	25	22	180	97	(1) 25	(1) 33	24	34	98	33
Working on equipment that is under pressure (calking, packing, etc. pressure vessels, valves, joints, pipes, fitting, etc., while they are under pressure)	(2) 53	6	(1) 1	4	3	28	2	1	(1) 4	2	2	
Working on equipment that is electrically charged (motors, generators, lines, and other electrical equipment without opening disconnecting switches, etc.)	(2) 24	(2) 7	4	3	1	2	2	....	....	...	5	
Working on equipment containing dangerous chemical substances (welding gas flasks, tanks, etc.)	(1) 9	1	1	1	....	....	..	......	1	...	1	(1) 4
N.O.C.*	(16) 146	(2) 62	8	13	12	12	9	5	(14) 14	3	7	1

NOTE: Figures in parentheses refer to fatal cases which are not included in accompanying figures.
* Not otherwise classified.

TABLE 8C.—INDUSTRIAL INJURIES RESULTING IN DISABILITY OF ONE DAY OR MORE, BY MANUFACTURING INDUSTRY GROUP AND UNSAFE ACT—YEAR 1939

Unsafe acts	Total manufacturing industries	Iron and steel	Non-ferrous metals	Transportation equipment	Textile and clothing	Food products	Stone, clay, and glass	Lumber products	Chemicals and allied products	Leather and its products	Paper and printing	Other manufacturing
Distracting attention, teasing, abusing, etc.												
Calling, talking, or making unnecessary noise	3	1	...	...	1	1						
Throwing material	2	...	...	...	1	1						
Teasing, abusing, or startling animals	(1) 38	1	...	1	...	27	1	(1) 3	2	..	2	1
Practical joking, horseplay	19	5	1	1	3	6	...	...	..	..	1	2
Quarreling	16	5	1	1	1	2	1	2	..	1	2	
N.O.C.*	46	6	...	8	4	20	...	3	3	1	1	
Failure to use safety or protective devices												
Failing to wear goggles, gloves, masks, aprons, shoes, leggings, etc.	(1) 1,557	(1) 767	110	239	41	68	98	46	67	37	42	42
Wearing high heels, loose hair, long sleeves, loose clothing, etc.	(2) 25	6	1	2	5	2	(1) 2	(1) 1	..	3	...	3
N.O.C.*	21	12	1	3	2	2	...	...	..	1		
Unsafe acts N.O.C.*	115	26	7	17	15	17	4	7	4	6	5	7
Unclassified—insufficient data	(27) 489	(9) 104	31	46	(5) 77	(9) 79	(1) 29	(1) 22	18	21	(1) 45	(1) 17
No unsafe acts	(16) 836	(5) 183	(2) 43	(1) 62	(2) 110	(3) 197	42	52	42	36	(2) 56	(1) 13

NOTE: Figures in parentheses refer to fatal cases which are not included in accompanying figures.
* Not otherwise classified.

APPENDIX VIII

RELATION OF AGE TO INDUSTRIAL INJURIES[1]

SUMMARY

During the last twenty years workers have repeatedly voiced their objections to discrimination against older workers in management's hiring policies. One of the reasons cited in justification for this policy is that the older worker is more of an accident risk than is the younger worker. In substantiation, it has been contended, first, that the physiological changes that accompany age decrease the speed of the older worker's reaction to danger, thus increasing his chances of getting hurt; and second, that once injured, his chances of recovery without permanent impairment are less and that his period of recovery is longer than for the younger worker.

The present article is an attempt to evaluate these contentions. It shows that older workers were injured less frequently than younger workers; but, once injured, they experienced proportionately more deaths and permanent impairments than did younger workers. Similarly, their healing periods in temporary disability were, on the average, longer.

The principal findings of available surveys in this field are summarized below:

Four plants—two of them public utilities, one a light manufacturing, and another a heavy manufacturing company—had during 1937 a working force of about 26,000. In terms of frequency rates—that is, the average number of disabling injuries per million hours worked—workers between forty and fifty-four years of age had rates only about two-thirds as high as workers under twenty-one, and 70 per cent as high as workers between twenty-one and twenty-nine. The rates for the forty to fifty-four year group were about on a level with those for workers between thirty and thirty-nine. The rate for workers of sixty and over was lower than that for workers under twenty-one, and about the same as for those between twenty-one and twenty-nine years of age.

The same trend is shown by an analysis of about 350,000 industrial injuries reported to the Wisconsin Industrial Commission during the period 1919–1938. It revealed that the percentage of injuries in the upper age groups was, as a rule, somewhat lower than the percentage of gainful workers in those age groups.

The Swiss experience, covering about 95,500 injuries during the period 1930–1934, showed that for every 1,000 man-years of exposure to the

[1] Excerpts from article by Max D. Kossoris, Bureau of Labor Statistics in the *Monthly Labor Review*, U. S. Department of Labor, October, 1940, issue.

hazard of industrial injury, older workers consistently had fewer injuries than younger workers. The frequencies of injuries per 1,000 man-years for workers between forty and forty-nine were less than three-fourths of those for workers between twenty and thirty-four. Of particular interest is the fact that the injury frequency for workers of sixty or more years of age was less than half that for the ages twenty to twenty-nine.

The Austrian experience quoted by the International Labour Office in its study, "Discrimination Against Elderly Workers," also pointed to the same conclusion. The accident frequency reached its maximum for workers between the ages of twenty and thirty, and thereafter fell steadily with advancing age. At fifty, it was only two-thirds of the maximum, and at age sixty, less than one-half. Although these decreases are much greater than those indicated by the available United States data, and probably explainable by differences in industries and occupations, they point in the same direction: injuries occurred proportionately less frequently to the older than to the younger workers.

Once injured, however, the older workers did not fare so well as the younger workers. The proportion of injuries that resulted in death or permanent impairment was considerably higher in the upper age groups.

The nearly 350,000 industrial injuries reported to the Wisconsin Industrial Commission contained 3,337 deaths. For every 1,000 injuries reported, workers between the ages twenty-one and twenty-five had an average of about six deaths. For the age group thirty-one to thirty-six, this number rose to 10; for ages forty-one to forty-five, it remained at about 10; for ages fifty-one to fifty-five, the rate increased to 12; for ages sixty-one to sixty-five, to 17; and for ages seventy-one and over, to thirty-six. Thus, workers in the forties had no worse a death-rate experience than those in the thirties. It was above fifty that the difference became marked. In this age group, the death rate was nearly twice that for workers in their twenties, and about 25 per cent higher than for persons in the thirties and forties. The rate for workers in the sixties, in turn, was nearly one-quarter above that for workers in the fifties, and about three-quarters again as high as for those in the thirties and forties.

The New York experience, with about 346,000 cases, showed the same trend. Workers in the twenty to twenty-nine age group had about seven deaths out of every 1,000 injuries reported; for workers between thirty and thirty-nine, the rate was nine; for forty to forty-nine, it rose to 12. From age fifty onward, the rate rose more steeply. The average of 19 deaths per 1,000 injuries for ages fifty to fifty-nine was nearly half again as high as that for workers in the forties. The rate of 33 for workers in their sixties, in turn, was nearly twice as high as for workers in the fifties, two-and-one-half times as high as for workers in the forties, and five times as high as for those in the twenties.

Although the New York and Wisconsin figures are not directly comparable for a number of reasons, they both emphasize, however, the high proportion of injuries resulting in death in the upper age groups. The New York data indicate further that the fatality experience of female workers, although less pronounced than that for male workers, is nevertheless in complete agreement.

The Swiss experience, likewise, showed a frequency of death per 1,000 accidents that was twice as high for workers between forty and fifty as for those under thirty, and about half again as high as for those in their thirties. Workers in their fifties experienced proportionately twice as many deaths as persons in the thirties, and about half again as many as those in the forties. Above sixty, and especially above seventy, the frequency of death rose still more abruptly.

For permanent impairments the differences are less pronounced but are still clearly discernible. In the Wisconsin experience, workers above fifty had about 13 per cent more permanent impairments per 1,000 injuries than workers of fifty or less. Workers between the ages fifty-one and sixty had an average of 98 such injuries as against 82 for the twenty-one to thirty-year group.

In the New York cases, workers in the forties had nearly one-third again as many permanent impairments as had workers in their twenties. Workers in their fifties had proportionately 50 per cent more impairments than workers in the twenties. And for workers above fifty years of age, the permanent injury rate was about one-quarter higher than for workers under fifty.

Similarly, when the older worker fully recovers from an injury, it takes him, on the average, longer to do so. For the four companies cited, the average healing period for workers between forty and forty-four was 30 days, as against 23 days for workers between twenty-one and twenty-four years of age. For ages fifty-five and over, the healing period averaged 34 days.

Wisconsin data, covering the years 1927–1928, showed an average of 21 days for temporarily disabled workers between ages twenty-three to twenty-seven, 28 days for ages fifty-three to fifty-seven, and 30 days for ages sixty-three to sixty-seven.

The same trend was followed in the Swiss experience, in which the healing period averaged twenty days for workers between twenty and thirty years of age, 30 days for workers of age fifty, and 34 days for age sixty-five.

The data on which these findings are based included nearly a million cases of disabling industrial injuries. This volume is sufficiently large to warrant reasonableness of the conclusions. However, the conclusions are not to be interpreted as justification for discriminating against the hiring of the older worker on the ground that he is a more *costly* accident risk. The relative cost of less frequent injuries of greater severity to older workers and of more frequent injuries of lesser severity to younger workers still needs to be determined.

LIMITATIONS OF STATISTICAL DATA

The data bearing on the problem of the relation of age to industrial injury are scattered and far from adequate. Nevertheless, they do point to several definite conclusions; although, before entering into a discussion of these and the supporting material, it is pertinent to call attention to several considerations which, because of paucity of statistical information, must be treated qualitatively rather than statistically.

Foremost in the deficiencies of available information is the lack of adequate exposure data. For any specified number of persons within a given age group who were reported to have been disabled through industrial injuries, how many were exposed to the hazard of being injured at their jobs? In the United States, for large geographic entities such as states, the statistics available are those compiled decennially by the census in the population count. Age distributions are shown separately for gainful workers but include both employed and unemployed. On the other hand, industrial injuries reported to state agencies such as workmen's compensation boards in practice never cover all gainful workers. There are usually omissions in coverage extending to specified industries, certain types of employment, or establishments with a specified minimum number of employees. Again, in a considerable number of states, injuries resulting in disability not exceeding a specified "waiting period" are not required to be reported. And, in a number of states which by law require the reporting of these "waiting period cases," the actual reporting of them is not strongly enforced and at times is actually discouraged.

Equally important is the absence of occupational data. If an adequate comparison is to be made for various age groups, it is desirable that these comparisons be made between workers in the same or similar occupations. Such occupational exposure and injury data, however, are practically nonexistent. At the same time, however, it must be pointed out that such data, even if they were available, would be subject to severe limitations. A considerable number of occupations require a degree of skill which only a protracted training period can develop. The same is true of hazardous occupations requiring considerable experience and maturity of judgment. Consequently, younger workers are automatically excluded from such occupations. On the other hand, the pace set by machines often bars from a number of occupations older workers who have not the required speed—either of action or reaction—and the necessary endurance. Similarly, a large number of manual occupations require an amount of physical strength not usually possessed by older workers.[1] Such jobs, in addition to being more arduous, are frequently also hazardous.

[1] The International Labour Office report, "Discrimination Against Elderly Workers" (London, 1938), cites the results of tests for functional efficiency, reported by E. Weiss in *Psychotechnik*, 1937, "Leistung and Lebensalter." The tests, conducted on unskilled workers, streetcar conductors, and locomotive engineers, showed that sensory alertness and physical dexterity began to fall off after forty-five and that mental faculties exhibited increasing unwieldiness from that age on. Older workers up to age sixty gave as good results as young men of twenty on daily routine work but had greater difficulty in adapting themselves to changed conditions.

Further, the same occupational designation often covers types of work and accident hazards which differ greatly from industry to industry and often between establishments in the same industry. A machinist whose function it is to keep power sewing machines in good repair is under an accident hazard quite different from one who has to repair heavy machinery. Further, variations in working conditions provide entirely different accident hazards even if the occupation is exactly the same.

These generalizations, of course, hold good only for workers as a mass. There is no question but that the physiological changes involved in the aging process—the atrophy of tissues, stiffening of ligaments, increasing brittleness of bones, decreasing accommodation of heart and eye, and the lessening of the recuperative power of the body generally—differ greatly as between individual workers.[1] Some workers at forty-five years of age are more aged physically than others at sixty.

[1] For a summary of impairments according to age, see New York Joint Legislative Committee on Unemployment, *Legislative Document* 33: "The Older Worker in Industry," by Solomon Barkin, Albany, 1933, pp. 104 and 107.

APPENDIX IX

BIBLIOGRAPHY

INDUSTRIAL SAFETY

American Engineering Council, "Safety and Production," Harper & Brothers, New York, 1928.

American Standards Association, Safety Codes and Standards.

BINGHAM, W. V., and C. S. SLOCOMBE, "Men Who Have Accidents," Personnel Research Federation, New York, 1927.

CHASE, STUART, "Men and Machines," The Macmillan Company, New York, 1929.

DEBLOIS, LEWIS A., "Industrial Safety Organization," McGraw-Hill Book Company, Inc., New York, 1926.

DOW, MARCUS, "Stay Alive," Marcus Dow, Inc., New York, 1928.

GRIFFITHS, ERNEST, "Injury and Incapacity—with Special Reference to Industrial Insurance," William Wood & Company, Baltimore, 1935.

LANGE, FRED G., "Handbook of Safety and Accident Prevention," *Engineering Magazine*, 1926.

LANZA, A. J., and J. A. GOLDBERG, "Industrial Hygiene," Oxford University Press, New York, 1939.

MICHELBACHER, G. F., "Casualty Insurance Principles," McGraw-Hill Book Company, Inc., New York, 1930.

National Conservation Bureau, "Handbook of Industrial Safety Standards."

National Safety Council, Safe Practices Pamphlets.

WILLIAMS, SIDNEY J., "The Manual of Industrial Safety," McGraw-Hill Book Company, Inc., New York, 1927.

INDUSTRIAL HYGIENE AND OCCUPATIONAL DISEASE

FICKLEN, JOSEPH B., "Manual of Industrial Health Hazards," Service to Industry, West Hartford, Conn., 1940.

GRIFFITHS, ERNEST, "Injury and Incapacity—with Special Reference to Industrial Insurance," William Wood & Company, Baltimore, 1935.

International Labour Office, "Occupation and Health" and Supplements, Washington, D. C.

Journal of Industrial Hygiene and Toxicology, The Williams & Wilkins Company, Baltimore, Md.

LANZA, A. J., and J. A. GOLDBERG, "Industrial Hygiene," Oxford University Press, New York, 1939.

McCord, Carey Pratt, and Floyd P. Allen, "Industrial Hygiene for Engineers and Managers," Harper & Brothers, New York and London, 1931.

National Safety Council, Health Practices Pamphlets, Chicago.

Sappington, C. O., "Industrial Health—Asset or Liability?" *Industrial Commentaries*, Chicago, 1939.

Sappington, C. O., "Medicolegal Phases of Occupational Diseases," Industrial Health Book Company, Chicago, 1939.

Zhitkova, A., "Some Methods for the Detection and Estimation of Poisonous Gases and Vapors in the Air; A Practical Manual for the Industrial Hygienist," Translated under the direction of Joseph B. Ficklen, Hartford, 1936, Service to Industry, West Hartford, Conn.

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