INVESTIGATION OF INDUSTRIAL ACCIDENT PREVENTION

Thesis for the Degree of B. S.

Earl J. Reeder

1915

Investigation of Industrial Accident Prevention

A Thesis Submitted to

The Faculty of

MICHIGAN AGRICULTURAL COLLEGE

By

Earl J. Reeder

Candidate for the Degree of

Bachelor of Science

June, 1915.

THESIS

FOREWORD

The purpose of this discussion is to formulate definite and logical conclusions concerning the prevention of accidents to workmen in industrial activities. Its preparation has included study of the small amount of literature available, relating to the subject, together with the results of personal observation of industries, mainly in the city of Lansing. In this connection, acknowledgement is due and is hereby given, of the kindness and assistance of the managers and others connected with the plants studied. The writer is particularly indebted to Mr. Robert K. Orr, Manager of the State Accident Fund, for valuable assistance in the preparation of this discussion.

INTRODUCTION.

Social and industrial economies are forcing upon the engineering world a new field of endeavor. Since the days when the engineers of the Pharaohs of Egypt and later, the emperors of Rome, built their magnificent structures through the labors of unpaid servants, with the most careless regard for life and limb, there has been a slowly progressing change in employment conditions. Recent years have seen a much greater change in this repsect than has any other equal period in the industrial history of the world. The nineteenth century witnessed the stamping out of the practice of slavery in our country and the few years of the twentieth

century that have already elapsed have left behind such an awakening of public sentiment against the existing physical hazards of industrial operation, that laws relative to this are being enacted.

In the last five years the legislatures of twenty-seven states have found it expedient to provide laws looking directly or indirectly to the greater improvement of working conditions in the industries of today. In these laws the inestimable value of human life is being recognized, together with the enormous economic loss occuring each year to employers, employes, and the general public through injuries sustained by workmen, resulting from poor conditions of employment. These laws provide for the partial remuneration to injured employes or their families, when death results, for injuries sustained while in employment. These laws are not so entirely new in principle but they are supplanting old employers' liability acts with their many imperfections and possibilities of evasion by employers, and are providing more nearly positive compensation to the injured employe through more stringent and definite provisions.

The burden of this additional liability to the laborer, must, of course, be borne by the employer either by direct compensation or through the agency of accident insurance. It is then, expedient for him to reduce the possibilities of accident in his factory or other unit of industry by such practical means as may be devised. Therein

lies the necessity for the new field of engineering endeavor, above mentioned, and from this it derives the name of "Safety Engineering".

Insurance companies operating under these compensation laws, are establishing departments of safety engineering with a view to recommending improvements in factories and other industries employing numbers of persons. These improvements are such that when fully incorporated in the indutries' operation, they tend to lower the accident rate in them so materially that a reduction in insurance premiums will be justified. There is now, in the early stages of development, a standardized method of applying merit or schedule rating to accident insurance risks, based upon inspections by the insurance companies' safety engineering departments.

It is with the means of accident prevention, rather than merit rating, that the writer wishes to deal in this discussion, the latter being mentioned as indicating the economic advantages of safety precautions to the owners of factories or other industries. However, a brief synopsis of those portions of the Compensation Law of our state effecting this particular subject, in operation at the present time, will not be inappropriate here, and immediately follows:

The Michigan Compensation Law is elective as distinct from the class called compulsory, i.e. employers and employes must choose between the old Employers' Liability Law, with certain modifications and the Workmen's Compensation Act,

within a definite period after employment begins. In electing to be under the Liability Act, which choice is assumed unless the employer files a written declaration of his intention to come under the Compensation Law, as stated below, the employer forfeits his right to plead the old defenses of contributory negligence, assumption of risk and fellow servants fault, in the event, of court proceedings for the recovery for injuries sustained by a workman in his employ. Such proceedings are the only means of settling cases of this class under the Liability Act. The employe's rights under the old liability law have not been curtailed by the Compensation Act. but remain substantially the same.

To accept the Compensation Act, an employer must file a written declaration with the Industrial Accident Board, indicating therewith, his sufficient responsibility or the fact that he has insured with some authorized insurance company which carries accident risks, or with the State Accident Fund. He must post printed notices of such acceptance within ten days from the date of its approval by the Industrial Accident Board. The employee's acceptance is presumed where his employer has elected to come under the law, unless notice is given at the time of hiring or within thirty days from the date of the employer's election. As stated before, failure to come under the Compensation Act by either party makes the Employer's Liability Act operative.

All public employments except such as officials

and all private employments except such as are casual and are not in the usual course, trade, business, etc. of the employer are covered by this act. All personal injuries arising out of, or in the course of employment, unless due to wilful misconduct, shall be subject to the provisions for compensation in the act.

The Compensation Law provides definite rates of remuneration for partial and total disability and for death of employes when the employer has come under the act, as follows:

1. Partial Disability: 50% of the average loss in earning power, not to exceed ten dollars weekly, must be paid for a period not exceeding 300 weeks, which sum must not exceed $4,000.00.

2. Total Disability: 50% of the average weekly wages, not more than $10.00 nor less than $4.00 , for a period not to exceed 500 weeks, must be paid, the total amount not to exceed $4,000.00.

3. Death: If the employe leaves a wife or children, 50% of average weekly wages, not to exceed $10.00 nor less than $4.00 must be paid for the remainder of the period between death and 300 weeks after the injury. If there are partial dependents such percentage of the above amount must be paid as the amount contributed by the deceased employe to such partial dependents bore to the annual earnings of the deceased. If no dependents are left by the death of the employee, reasonable expenses of the last sickness and of the burial of the deceased must be paid, the amount not to exceed $200.00.

4. Specific indemnity for loss of member or members, as a hand or a foot.

I. General Considerations.

Little literature is available, as yet, upon industrial accident prevention, owing to the very few years that have elapsed since its inception, as a distinct and important field. In this particular section it is the writer's desire to somewhat briefly outline the general field of the work, bringing together those phases treated separately and to greater length by writers of magazine articles, pamphlets issued by insurance companies and such other literature upon the subject as is accessible.

It is a noteworthy feature that manufacturing plants lend themselves most readily to the efforts of the safety engineer and that the large field of construction work has little attention. This condition has arisen through the fact that there has not, as yet, been developed any practicable system of merit rating for insurance premiums in construction work and hence no apparent necessity has arisen from the economic standpoint for attention. Further, the very nature of the industries is such as to preclude ready standardization of accident prevention means and methods, owing to the constantly changing conditions in any construction work. Hence, in this discussion, little if any, attention will be given to this phase of safety engineering and treatment will be confined to manufacturing industries alone.

Writers upon this subject accord completely in dividing accident prevention into three distinct parts, representing as many definite branches of endeavor in perfecting safety conditions. These are, briefly stated, organization, education and safe-guarding.

Organization - Though no detailed system of organization is universally applicable to all manufacturing plants there are certain basic elements which might well serve as the foundation of safety organization in all. The purpose of a safety organization should be the establishment of cooperation between employer and employe for the improvement of conditions on which depend the safety of the latter while at his work.

One of the first requirements of an efficient organization is a provision for careful inspection at frequent intervals, for the detection of any conditions contributing to the occurence of accidents. Such inspection should be so conducted as to promote the greatest possible degree of cooperation between management and workmen, both to inspire confidence in each other and to bring out the most immediate necessities as they present themselves to the workmen in their daily experiences. This may be done by special workmen's inspection committees and a safety isnpector who may or may not have other duties but whose primary duties consist in the supervision of safety work.

Another requirement is an efficient and active administration of the safety campaign. Here also, the workmen should be represented, probably, by department foreman. In

order to effect the most efficient administration a committee of superintendents and foremen should constitute the body which authorize all safety work.

A third requirement is strict supervision and carrying out of all authorized methods in safety work. The success of a safety campaign depends upon the degree of care used in its operation. Such supervision should be placed in the hands of the safety inspector.

In an article contributed to the Safety Engineering magazine for January 1915, by C. W. Price, Assistant to the Industrial Commission of Wisconsin, and member of the Executive Committee of the National Safety Council, he states that in five years experience in the various industries in Wisconsin, which have made the largest reductions in accidents, two-thirds of the reductions have been accomplished largely through organization and education of employes. The conclusions of Mr. Price which seem also to be held by other writers, show the importance of organization in safety engineering work. Mr. Robert W. Campbell, President of the National Safety Council, in an article in the Compensation Journal for April 1914, places organization as affording 45% out of a possible 100% efficiency in accident prevention. EDUCATION. This subdivision of safety engineering is given second place to organization by Mr. Campbell in the above mentioned article, as affording 30% efficiency. Methods of education of employes, in safety work, are not nearly so definite nor so extensive as are those of organization. Such methods consist in general, in educating the employe into

habits or carefullness in his work. Lectures, sometimes illustrated by lantern slides, posting of signs of warning in dangerous places, distribution of prizes, such as badges, etc. to men in departments in which the least number of accidents occur causing lost time, and personal instruction of the men individually are among the various devices adopted. Undoubtedly, foremost among these is the last named, personal instruction. In this line is the employment of interpreters for foreign employes, and the practice of interviews with the employes at their machines, pointing out the elements of danger in their particular line. Herein, foremen fully in sympathy with accident prevention means and methods may render very effective service as instructors.

SAFEGUARDING. Mr. Price in his article mentioned above, states that the experience of the companies which have done the most systematic work in accident prevention, shows that practically every point of danger on machines can be covered with a simple, effective and inexpensive safeguard which does not interfere with the operation of the machine. While safeguards are the most positive and dependable means for the prevention of accidents of the class to which such means are applicable, unfortunately for the work of the safety engineer, machine accidents constitute a minor part of all the accidents which occur in industrial pursuits. Wisconsin statistics given by Mr. Price, show that in that state, between 30% and 35% of the total number of accidents causing disability of seven days or more occur in the operation of machines. Mr.

Campbell places safety devices at 17% efficiency in the prevention of accidents, and gives 5% to lighting and 3% to cleanliness, making a total of 25% efficiency for safeguarding. Edward T. Walsh, M. E. is, at the time of this writing, contributing to the Safety Engineering Magazine, a series of articles on "Accident Prevention Through Good Ventilation" in which he shows the importance of good ventilation as a means of safety. It seems that Mr. Campbell erred somewhat in not giving some place to this important factor in his classification.

GENERAL ACCIDENT CAUSES. Foremost, among the causes contributing to the occurence of accidents, is carelessness. Constant exposure to danger has the effect of deadening the sensibility of the workman to the precarious conditions surrounding him, and prompts him to take many chances which in the absence of familiarity he would readily recognize as positively dangerous. It is mainly for the elimination of this class of accidents that the safety organization has been conceived. Some one has aptly said that a thinking workman is a "safe" workman. The workman who has a definite interest in his work is the "thinking" workman. To this end the spirit of cooperation developed by the safety organization, serves an important purpose.

Another factor contributing largely to the occurence of accidents is the ignorance of the workman of the dangers which confront him in his daily work, or to which he may be exposed occasionally. Such ignorance may lead him innocently into dangers which he would carefully avoid did he realize the real hazard to which he was exposing himself.

A carefully conducted educational campaign among the employes with a view to bringing to their attention the points of danger, is the logical solution of such a problem as above outlined.

The third great class of accident causes consists of those which arise through dangers inherent in ordinary operation of machines wit hout safeguards or occuring through defective machines and other factory appliances, all of which refer mainly to the manufacturing industries. Added to these items, in order to make this class include all causes not covered by the other classes enumerated, should be those dangers inherent in the construction industries and such others as may logically fall under this head. The general remedy prescribed, vitally insufficient and indefinite as concerns construction work, but well defined in its application to manufacturing industries, is safeguarding.

With the above general treatment of the causes and remedies of accidents as a basis, a detailed treatment mainly from the writer's observation in the study of various industries may now be attempted.

II. Detail Treatment.

It is intended in this section to treat in comparative detail the conditions encountered in the inspection and study of eighteen factories, sixteen of which were in Lansing, one in Jackson and one in Grand Lege. These factories were selected rather indiscriminately for study, in order that the average results might be obtained, yet an attempt was made to have as many industries as possible represented. It is not the desire of the writer to treat separately, in detail, each factory visited, but rather, by study and comparison of the conditions prevailing in the various ones, to arrive at a knowledge of the general tendencies, activities and sympathies toward accident prevention and to study the effects of these upon the industries.

A table showing the nature of the industries inspected and studied follows:

INDUSTRY. Table I.

	No. Visited.
Automobile manufacturing	3
Gas Engine Mfg. with and without foundries	4
Machine Shops (general, screw mfg. etc.)	2
Foundries	1
Forge Works	2
Wood working Shops (auto bodies, wheels, wheel-barrows, etc. with and without machine shops, etc)	5
Clay products manufacturing	1
Total	18

An attempt has been made to show, in the following table, in a brief and comparative way, the conditions encountered in the inspections made. It does not show the

actual conditions existing in detail, but it does show at a glance the extent to which the various phases of accident prevention are being used, in the opinion of the writer.

TABLE II.

Features.	Number Practicing Feature. Good.	Fair.	Poor.	None.	Total.
1. Sympathies of management toward accident prevention	4	7	7		18
2. Safety organizations	1	1		16	18
3. Educational facilities	1	5		12	18
4. Cleanliness and order	6	9	3		18
5. Light	10	5	3		18
6. Ventilation	11	5	2		18
Safeguarding					
7. Transmission(belts, gears, shafts)	1	7	10		18
8.Machines(various dangerous parts)	2	6	6	4	18
9. Elevators, hoistways, etc.	5	2	2		9
10.Stairs, elevated runways,ladders	7	6	3		16

The first item in the above table, sympathies of management, is based upon the general attitude of the superintendents, factory managers and other officials interviewed and the general impressions arrived at through inspection. The figures show that in the opinion of the writer, only about 20% of the factories visited were operated by men fully in sympathy with safety work. Another 40% were only fairly interested and the remainder, (40%) were without apparent

interest in the subject.

Out of the eighteen factories inspected, only two have safety organizations. One of these consists of a committee of three workmen, one appointed each month, who make weekly inspections of the factory and file written reports of hazardous conditions, with the superintendent who then requests that they submit suggestions for improvement of such conditions to him, after which he passes upon such suggestions to authorize their adoption, if satisfactory. This factory has done more toward safeguarding and education of employes than any of the other seventeen. Another factory has a safety committee of seven workmen, mainly foremen, but the conditions in this factory are not such as to indicate that much has been done by this committee, since, in many respects the factory is very deficient in its safety devices and appliances. The attitude of most of the other factory operators toward safety work shows, the writer believes, that their failure to provide for workmen's organizations is not so much an indication of the ineffectiveness of such organizations as it is of the failure of the operators to realize their true value. The gist of a statement frequently made by the factory managers and superintendents during this series of inspections, was that guards had been provided for dangerous machines and other points of hazard and that all other possible precautions must rest with the workman himself, since the operators had done all that they could do by installing the guards. Such a statement entirely disregards an important factor in the

condition of labor.

The workman is expected by his employer to produce the largest output reasonably possible in his work. Under the fear of discharge, he often takes many chances and exposes himself to many dangers in order to perform the greatest amount of work with the least actual exertion. While in most cases it is not the intention of the employer that the workman shall expose himself to unnecessary dangers in his labor, yet the latter undoubtedly often fails to realize the formers real intentions and there exists between the employer and employe a misunderstanding, the former interpreting the latters attitude as that of pure carelessness while the workman feels that he is laboring to the better satisfaction of his employer. There exists therefore, a lack of cooperation which could be supplied to a large extent by organizations established for the purpose of creating a more thorough understanding between these two elements of industry and in which employers and employes join their efforts for the advancement of physical safety. Despite the small percentage of factories encountered in these inspections, which support any type of safety organization, it is still the writers firm belief that such organizations should exist in every plant where conditions permit. Perhaps in some the employes are of such a transient nature that attempts at cooperation would be futile, but the vast majority of manufacturing plants are well adapted to the support of workmen's safety committees and inspection departments.

Though education is closely allied with organization as regards its objects, a larger number of the plants inspected have taken steps toward the education of their employes. Foremost among these was the one already mentioned as the best equipped factory inspected, from the standpoint of safety precautions. Their excellent organization serves as an important educational medium for those employes who have acted upon the committee. General printed instructions are provided the workmen when hired and special instructions and warnings for various points of danger are conspicuously posted. Such instructions are always brief and designed to attract the attention of the workmen. No instructions are allowed to remain after they have served their purpose, to confuse workmen and distract their attention from new and important notices. "Safety First" notices in green and white are placed at frequent intervals in conspicuous places. As an additional precaution all machine guards and other safety appliances are painted red, which serves to call the workman's attention to them.

Some other factories have engaged in educational work in varying degrees but none so extensively as the one mentioned above. The usual means adopted is the posting of danger signs. Individual instructions to machine operators are important items since they bring to the individual attention of the workmen the dangers in connection with their particular work.

Undoubtedly, the reason for the fact that more

plants have adopted some form of educational work than have adopted organization, is that the needs and results are more directly apparent and the sympathies of the manager lay with the prevention of that class of accidents (namely those due to ignorance), which it is intended to prevent, more than with those due to apparent carelessness on the part of the employee. Nevertheless, the law does not discriminate against either class of accidents but holds the employer or insurance company equally liable for both, unless the accident is due to wilful misconduct. Consequently, neither education nor organization should be belittled by the employer in his accident prevention campaign.

A factor which is of importance in plant operation and which effects, to some degree, the accident frequency is the cleanliness and general order. The tendency among most plants is to hold a rather high standard in these respects, yet three of those inspected were classified as poor, mainly through lack of care in piling materials and ridding floors of unnecessary refuse. Greasy and littered floors near working machines are dangerous, especially where the operators are exposed to such conditions. I found such conditions eliminated very effectively in some cases by a slightly raised platform made of slats through which small particles could pass out of the way of the operators feet, and on which the workman could stand while operating his machine. In some factories very effective use was made of boxes or

cans, mounted upon sufficiently large casters to insure ease of movement, as containers for pieces of stock used by the workman. This eliminates a great deal of the hazard of stock scattered promiscuously upon the floor and enables an attendant to remove finished parts and to supply new stock to the machine operators with greater facility. Though these are frequently used in the wood-working shops but not so frequently in the machine shops, there is no reason apparent why such a method is not equally applicable to the latter. Poorly defined aisles due to scattered materials, tend to expose men to dangers both from machine parts and from falling, which could and would be otherwise avoided by them. Cleanliness and good order not only aid in the reduction of accidents but add to the efficiency of the workman as well.

As an indication of the dangers of slipping and tripping, the fact that out of 25,991 non-fatal accidents classified in a recent report of the California Industrial Accident Commission, 1634 were due to these causes, may well be cited. In addition, 1,125 occured as the result of handling objects in shops. Out of 54 classes of accident causes, slipping stands sixth in the number of accidents resulting in this report. From this, the real importance of precautions to prevent such accidents is very apparent.

The lighting of a plant plays an important part in the accident frequency, while its real importance cannot be directly shown by actual figures based on the experience of operating plants, a little reflection will convince one of the possibility of accident through lack of sufficient light to enable workmen to see the dangers at hand. This is particularly true of machine operation, since rapid revolution of projecting parts, such as set screws, gear teeth, etc. renders such parts invisible, except in good light. Where these are protected the danger is considerably decreased, but even in such cases a workman's actions cannot be so rapid as where good light is provided him. Hence, it may be seen that not only from the standpoint of accident prevention, but from that of efficiency, good lighting is to be desired.

Of the eighteen factories visited, ten were lighted in an excellent manner, five had fair facilities and three were poorly provided. One of the first number was equipped with gas lights as an aid to excellent conditions of natural lighting, others used electric lights in this capacity. In some factories the only lights used in places that were naturally dark were incandescent lamps, near the working points of the machines themselves. These served the purpose of lighting those particular parts, but aisles and spaces between the machines were very poorly lighted and presented conditions of considerable hazard in the opinion of the writer. The general

tendency is toward good lighting in most of the factories.

The part of ventilation in accident prevention is not so readily established and accepted as that of lighting. However, the effect of foul air upon the efficiency of the workman is generally understood to be detrimental. It is a fact of general knowledge that poor ventilation impairs the mental activity and produces a sluggish brain. It is, then, only logically conoluded that the workman's safety in the presenne of any danger, is impaired considerably by his decreased carefulness and alertness.

Good ventilation existed in eleven of the eighteen factories, five had fair conditions and two were very deficient in this respect. The general tendency is then seen to be to provide good air and freedom from dust. Both conditions are produced in the majority of cases by forced draft. Among the wood-working shops the use of local forced ventilation to remove any dust produced by machines is particularly prevalent.

The field of safety work which lends itself most readily to the safety engineer is guarding. While the class of accidents which can be prevented by this means is held by safety experts to be a minor portion of

all accidents occurring, the direct needs and proper remedies are most easily observed and consequently receive first attention in a safety campaign.

In an attempt to gain some idea of the proportion of machine to other accidents, occurring in an ordinary factory, the writer has classified the accidents for definite periods occurring in four Lansing factories. The methods of keeping records practiced by the various plants being generally different, any attempt at uniform classification is undesirable. The nature of the factories whose accidents were studied are as follows:

1 automobile factory.
1 gas engine factory.
1 wheel barrow factory.
1 wagon factory.

The first classification (table III.) is for the automobile factory for the months of November and December 1914, and January, February and March, 1915, and includes both the cases where doctors were employed and where treatment was given entirely in the plants' emergency hospital.

It is made on the basis of the occupation of the injured workman and consequently does not truly show the number of accidents on the various classes of machines since some accidents occurred to machine operators while they were temporarily engaged in other work and machines were undoubtedly responsible for accidents to others than their operators.

Table III.

Occupation	Number.	Machine Accidents%	All %
Grinders	296	39.8	
Lathe Operators	271	26.3	
Drill Operators	166	16.1	
Milling machine Operators	97	9.4	
Punch Press Operators	94	9.1	
Shaper Operators	63	6.1	
Miscellaneous machine operators	43	4.3	
Total Machine Accidents	1030	100.0	43.7
		% of others	
Assemblers	365	27.5	
Truckers	98	7.4	
Tinners	110	8.3	
Trimmers	47	3.5	

Occupation	Machine Accidents. Number.	% All Accidents. %
Toolmakers	47	3.5
Machinists	37	2.8
Inspectors	50	3.8
Laborers	80	6.0
Die Makers	29	2.8
Repairmen	44	3.3
Carpenters	27	2.0
Electricians	33	2.5
Mill-Wrights	19	1.4
Miscellaneous	341	5.8
Total of hand labor accidents	1327	100.0 . 56.3
Total Accidents	2357	

Table IV. shows the number of accidents occurring in the gas engine plant since the beginning of their records in 1912. This plant is the one referred to as the best equipped of those inspected. The classification here is based on the nature of the accidents.

Table IV.

Nature of Accident	Number.	Percent.
Accidents to Eyes	61	57.0
" due to revolving parts	20	18.7
" " " falling objects	11	10.3
Miscellaneous	15	14.0
Totals	107	100.0

Table V. is made from the accident records of the wheelbarrow plant for the year April, 10, 1914 to April 10, 1915, and is based on the accident causes with special references to some of the most dangerous machines.

Table V.

Cause	Number.	% of Machine.	% Of All
Grinding	5	23.8	
Wood & Iron Drills	5	23.8	
Saws	2	9.5	
Planers	1	4.8	
Miscellaneous Machines	8	38.1	
Total Machine	21	100.0	35.6
Falling objects	7		
Foundry work	3		
Miscellaneous	28		
Total Non-machine	38		64.4
Total Accidents	59		

Table VI. classifies the accidents of the wagon plant since the beginning of the records, according to nature and causes combined.

Table VI.

Nature or Cause	Number	% Of Machine.	% Of all
Sawing	3	23.0	
Accidents to Eyes	3	23.0	
Sanding	2	15.5	

Nature or Cause	Number	% Of Machines	% Of All
Wheel trueing	2	15.5	
Other machines	3	23.0	
Total Machine	13	100.00	44.8
Falling Objects	5		
Falls to men	3		
Miscellaneous	8		
Total Non-machine	16		55.2
Total Accidents	29		

From Tables III. V. and VI. it will be seen that between 35% and 45% of the accidents occurring in these plants considered separately, were sustained by machine operators and that about 25% of this class are injuries to eyes. These are mainly sustained in the operation of grinding machines of various kinds. Lathes, saws, and drills are indicated as hazardous machines by these classifications, partly due to their greater number, but due mainly to their dangerous nature. Though these classifications do not show accidents sustained through belts and other transmission equipment separately, the real danger of these is indicated by the California Accident Board's Report, mentioned above, by the fact that belting lines and pulleys were responsible for 6.0% of the accidants due to mechanical causes. While the classifications given above show the general conditions in the four

factories from which they were made, they are not sufficiently general to be truly indicative of the hazards of different classes of machines and equipment. In order to supply some causes of accidents not touched upon in these tables the writer has selected fifteen of the fifty-four classes tabulated in the California Report, treating only accidents due to mechanical causes, but quite thoroughly covering this field, and tabulated them with the percentage of the total number represented by each class. These accidents were non-fatal but occasioned temporary disability. This tabulation is given in table VII.

Table VII.

Machine causing Accident	Number	Percent.
Motors and engines	582	20.8
Emery Wheels	367	13.0
Saws	278	9.9
Belting lines and pulleys	170	6.0
Drills, punches and dies	132	4.7
Gearing	102	3.6
Lathes and shapers	90	3.2
Feed rolls	66	3.1
Presses	74	2.6
Shafting and conveyors	70	2.5
Jointers, edgers, slicers and stayers	44	1.5

Machines causing Accident	Number	Percent
Planers, veneerers, sanders	37	1.3
Set screw	21	0.7
Cogs	16	0.6
Elevators and hoistways	324	11.6
Miscellaneous	420	14.9
Totals	2813	100.0

Treatment of the subject of safe-guarding with reference to the inspections may best be considered under four heads, i. e. transmission, including belts, gears and sprockets, separate from the machines, machine guarding including all means provided for protection of workmen against dangers inherent in the operation of the machines themselves, elevators and hoistways, stairs, elevated runways and ladders. These heads represent four distinct divisions of activity in safety work.

The great tendency among the plants visited is to disregard the hazards of unprotected belts, but gears and sprockets are as a usual thing fairly well guarded. Only one factory could be classed as really well guarded in this particular. The main features of transmission besides gears and sprockets are horizontal over head, and vertical and inclined driving belts. In few plants is any attention given to the guarding of horizontal belts except where they are six feet or less from the floor, the reason for guarding in which case being very evident. The danger from large horizontal belts breaking and injuring workmen is considerable, particularly when such belts are running at high speed. This danger is eliminated in

some factories by supporting closely beneath the lower side of the belt a board, wire mesh, or sheet metal guard, and turning such guard up past the pulley to act as a container for the belt in the event of its breaking. However, the use of such guards is not general.

Regarding vertical and inclined belts most plants provide some means of guarding the larger ones where they run on a pulley near the floor but such guards do not usually extend to sufficient height to afford complete protection. The usual materials for such guards are lumber, wire mesh and angle irons, or gas pipe railing. The wire mesh guards are the most desirable, owing to their ease of removal for access to belts and pulleys, general appearances and the small space occupied by them. Where sufficient space is available a substantial gaspipe railing 3 ft. 6 in. in height placed not less than 15 inches from the belt or pulley affords good protection. Any guard placed closer than 15 inches should be of such character as to prevent clothing or other materials from coming in contact with the moving belt or pulley and hence should be wire mesh, wood slate or boards, the wire mesh being preferable, and should extend to a height of about six feet above the floor or platform.

One factory which the writer inspected was using individual motor drive for the machines, most horizontal belts being eliminated, as were also many of the vertical ones, which would be necessary for group driven machines. Besides the high efficiency of such a plan which is

generally conceded, it has the advantage of decreasing the accident hazards very materially.

Stairs and elevated runways are to some extent dangerous when not well maintained and provided with sufficient rails. Reference to Table II. will show that safer conditions exist in this classification of safe-gurading than in any other except elevators and hoistways. The dangers from defective and unprotected stairs and runways are so apparent that careful attention is usually given them to avoid accidents.

Elevators and hoistways have in the past, been the source of many accidents and reference to Table VII. will show that this class stands well up in the list of mechanical accidents in California, from the standpoint of number. However, the writer's inspections of the eighteen factories, mentioned heretofore, revealed good conditions in this respect. Most elevators were exceptionally well guarded by having their shafts enclosed on at least two sides and automatically operated gates provided for the other sides. A few, however, were not so guarded and were unmistakably dangerous. An automatically operated gate and closed sides do not in any way detract from the efficiency of operation, nor lessen the advantages of an elevator in any way, but they do provide practically safe conditions and a much better appearance.

By far the most important part of safe-guarding has to do with machine parts. The large number of

machines and the close contact of the operators with them, are the features responsible for this condition. The different makes and kinds of machines are of such large number that any attempt to treat them separately as to hazards and possible guards, would be scarcely within the limits of this work but a general treatment of some of the most important and hazardous classes as revealed by inspection and study will be attempted.

The largest class of accidents to machine operators revealed by the records studied, occurred in the grinding of tools and castings, and this is not surprising when one sees the number of grinding machines being operated without sufficient protection for the men. In but few cases were goggles worn by the workman to protect his eyes from flying particles of emery, yet this is the nature of the vast majority of grinding accidents. Enclosing cases for the wheels are not in general use but iron band guards are used in the majority of cases. These are however, neither effective protection against flying particles of emery nor against danger from explosion of the wheel.

Next in number, to the grinder accidents are those occurring on saws, these being undoubtedly the most hazardous machines in a wood-working shop. Band saws can be very effectively guarded and in most cases they were found to be well protected, but the main difficulty encountered is with the circular saw. Several different makes of guards for these saws are upon the market and a number of

these have been installed in the shops inspected, but they were not being generally used by the workmen. From the standpoint of efficiency of operators and effectiveness in accident prevention, most of these guards are undoubtedly beyond adverse criticism, but the failure to use them seems to be due to the idea of the workmen that they are amply able to protect themselves without mechanical guards. However, the large number of saw accidents that occur show plainly that such guards are highly desirable.

Lathes when not properly guarded afford many points of danger, the most important being the many gears and the chucks and dogs. Fortunately, the gears are usually enclosed when the machine is made but the chucks and dogs must be taken care of by the plant using it. These latter items are given little attention in most of the factories inspected, some however, using sheet metal guards around the chucks to prevent contact of the workman with the moving parts. A particularly dangerous class of lathes are those in which the material being worked extends through the head stock of the lathe some ten or twelve feet, as in the making of screws. In one of the factories inspected a workman had been caught by revolving material and whirled about before the machine could be stopped. This accident resulted in the providing of pieces of iron pipe as containers in which the projecting stock runs.

The wood shaper as usually made, is very hazardous and permits of little guarding. Some factories are using the new type of cylindrical head for the knives, which are so constructed that contact with the revolving knives will only cause a slight paring of the flesh instead of the removal of one or more fingers as was possible with the old style of square head. In addition to this, forms are frequently used having the general outline of the finished article, to which the stock is attached by clamps. By the use of these forms the probability of contact with the knives by the workman is greatly reduced. Such forms can also be used for some other wood making machines where only certain finished shapes are being produced. The cylinder head is also used on many buzz planers to lessen the possibility of serious injuries.

In addition to these machines, specifically considered as the most hazardous, are many others which present varying degrees of danger to the workman. In fact it might truly be said that any machine is, in some degree, dangerous and needs the installation of guards to insure absolute safety. Reference to Table II. indicates that safe-guarding of machines has not been very completely carried out in the factory inspected, it being possible to class only two of the eighteen factories as good in this respect and in four of the number, machine guards were practically or wholly lacking. The superintendent of one of these factories seemed disposed to ridicule

the whole program of accident prevention, as unnecessary and wasteful. It is of interest to note that in the construction of new plants the tendency is to give particular attention to installation of safety appliances. One of the plants inspected was in the final stages of construction and installation, it being planned to commence operation May 1st. Many safe-guarding devices had been installed and plans were made for others, which when completed would leave little to be done to insure the employe's safety so far as such is possible through the medium of safe-guarding.

III. Conclusions and Suggestions.

Employers are becoming generally convinced that accident prevention has its place in the industrial world. A few seriously doubt its real need but in the main, some degree of safety work is being attempted in nearly every plant. As might be expected in any new line of endeavor, the first steps are being taken in that branch of accident prevention in which needs and results are most readily seen, i. e. in that branch in which mechanical safe guards serve as the means of protection. Plant inspection reveals the fact that very little system is being practiced even in this field for it is very common to find some point of danger guarded, but several others of exactly the same kind in the same plant, entirely unguarded. The evident need of every plant in its safety work is a systematic

plan of attack. It is the writer's intention to outline in this section what he considers to be the essential elements of a systematic safety campaign.

The primary need is effective administration which should be in the hands of men thoroughly in touch with shop conditions. Undoubtedly the factory manager or superintendent should head a committee for this purpose. The body of workmen should be represented through some of their number or their foremen, both to effect co-operation between employer and employe and to give the committee the advantage of the workman's more intimate knowledge of the hazards and danger of the plant, through his own experience.

Careful inspection for the detection of the more evident dangers is highly important. This should not rest alone with the safety engineers of the insurance companies as is the case with many plants whose managers make their safety improvements upon the recommendations of factory inspectors alone. While the factory inspector can offer valuable general suggestions, his knowledge of any particular plant, is , of necessity, not sufficiently intimate to enable him to touch upon the many important details which are not always evident upon ordinary inspection. Safety inspectors and workmen's committees for each plant are available solutions for the inspection problem. Whatever means is adopted should be such as to result in careful periodic inspections of the entire plant.

Careful supervision of all installations of guards and other appliances should be practiced. Where a safety inspector is employed, which should be the case in plants of sufficient size to forbid these duties resting with the manager or superintendent, he should supervise the work. Careful judgment should be exercised in the selection of the proper kind of guards and appliances to be installed, to be sure that they are effective and not detrimental to the efficiency of the workmen.

The real value of accident records properly kept and classified is not generally recognized among plant operators. In preparing Table III. the writer looked over nearly 2400 separate records, any classification of accidents in this plant being entirely lacking. Valuable use could be made of these records by the company owning them , were they properly classified to indicate the importance of accident causes. Accident records should be carefully kept and used for the determination of hazards and the effectiveness of safe guards and other methods of accident prevention.

A fault which is apt to creep into the keeping of accident records and one which renders many tables and records prepared with much effort, of little value to those who attempt to study them to determine facts concerning the prevention of accidents, is the failure to supply data showing the actual number of men or the value of the payroll exposed to the dangers of the particular machine, department or type of plant in question. This exposure

may be expressed for any give. period, as one month or one year, by reducing the total number of hours put in by the workmen to the number of men working, say, eight or ten hours per day, during the time or by direct statement of the payroll duing the period, depending upon the nature of the record desired. In the one case the actual frequency for the period can be determined on the basis of the men represented by the number of hours put in by all men that were employed during the period. On the payroll basis the economic features of a safety campaign can be compared one month or one year with another. These are some of the possibilities of such records and various factory or plant conditions would, no doubt, suggest others.

Another essential of a systematic safety campaign is a definite and effective educational move. In the writer's opinion this should be established simultaneously with the organization in order that the workmen may be informed of the exact purpose of the move, from its beginning. False impressions of the motive of the employer are so easily gained by the employes and the real purpose and success of such a project so greatly impaired thereby, that no time should be lost in acquainting the employes with the plan.

A variety of different educational plans are possible, depending mainly upon the nature and size of the plant and the kind of men employed. Foreign employes would need entirely different attention from Americans

and in large plants an essentially different system is possible than in a small one. Nevertheless, printed instructions, danger signs, warnings, and "Safety First" notices, and personal instructions are universally applicalble. In addition, lectures, prizes for best accident records and various other incentives to the employes to keep their safety in mind, are effective means for education in the prevention of accidents.

Conditions of light, ventilation and general order should receive early attention. In any plant the lighting should be general, instead of local or provided for individual machines separately, and should be bright, but not glaring. Ventilation should be provided in such manner and to such degree that clear thinking of the workmen will be induced. Dust collecting systems should be provided in all localities of a plant where dust is created. Careful piling of materials, clean floors free from grease and shavings and other refuse, and safe and efficient means of transportation of materials about the plant are features that should be carefully maintained.

It is very important in the establishment of a highly effective safety campaign that the safe-guarding be done in a systematic manner. Promiscous safe-guarding is not efficient and is not conducive to good results. It is not possible to provide guards for all points of danger at once, but rather the work of safe-guarding must progress

only as rapidly as conditions in the plant will permit. Such progress should be made along definite lines, attention being paid first to the points of most hazard. For example, the greatest accident hazards in a certain plant may be in its transmission facilities. In such a case, the safe-guarding of the belts, gears, shafts, etc. should receive the first attention. In a new plant where the experience of the managers has not been sufficient to enable them to determine the points of greatest hazard in this particular plant, the judgment of the safety committee must be the deciding factor in the laying out of the safety program. In no case, however, should the work be carried on in any other than a systematic way, i. e. by completing the safeguarding of one type of hazards before another is attempted.

In the construction of a new plant the safety of the men to be employed should be an important factor in the laying of the plans. It is during construction that some means of safe-guarding can best be carried out, among these being the proper location of machines, safe construction of elevators, installation of the best means of transmission of power, provisions for proper lighting and ventilation and the use of high class floors and stairs.

Care should be used in the employment of workmen, to select those whose sympathies and habits are such as to make them careful and thoughtful regarding their own safety and that of their fellow workmen. Those habits which render

a workman incapable of clear and active thinking add to the hazard of his work and decreases his efficiency and consequently make him an unprofitable employe.

In conclusion, the writer's opinion is that "Safety" means "Efficiency" and "Economy" within reasonable limits, in plant operation. Consequently the humanitarian point, apt as it is to be unpopular with employers, need not be over worked in the justification of the prevention of industrial accidents in the manufacturing industries. Lack of activity in this line in the past was probably due to a large degree to the failure of the Employers' Liability Laws to hold the employer responsible for accidents to his workmen while in his employ, but with the adoption of more stringent laws the matter of economy has taken a definite and unmistakable form.

In nearly every point that has been taken up the essentials of accident prevention are identical with those of efficiencty. Stiff competition is bringing efficiency to the front as an essential to good plant management. In connection with this development and its relation to accident prevention, we may bespeak for the latter an easier way than has confronted it in the past, especially in so far as the more up to date and progressive plants are concerned with it.

Original Outline

Introduction.

(a) General social and economic conditions on which legislation providing for Industrial Accident Prevention and Compensation is based.

(b) Michigan Compensation Law.

1. General study of means being used for the prevention of accidents.
   (a) Organization of employes
   (b) Education of employes
   (c) Safeguarding
2. Detailed study of means regarding
   (a) Effectiveness
   (b) Employes' efficiency
   (c) Economy to Employer
   (d) Obstacles
3. Summary, general conclusions and suggestions for improvements.

A List of Accident Prevention Literature.

"Machine Shop and Foundry"- Carl M. Hanson, M. E.
Universl Safety Standars Pub. Co. New York.

"Safety" - Wm. H. Tolman Ph.D.
Safety Engineering, 80 Maiden Lane, New York.

"Safety Engineering Magazine" - Published by above firm.

"The Travellers Standard" - Published monthly by the
Travellers' Insurance Company, Hartford, Conn.

"Safe guards" David VanSchaak
"Woodworking Safe guards" Van Schaak
"Elevators"
} Published by Aetna Life Insurance Co. Hartford, Conn.

"Circular of Bureau of Standards" -
Department of Commerce - Washington.

"Steelcrete Guards" - catalogue by the
The Consolidated Expanded Metal Co. 101 E.40th St.
New York.

"Safety Guards" - catalogue
Lockhart-Hodge Co. Inc. Buffalo, N. Y.

I N D E X.