ACCIDENT PREVENTION
and the conservation of manpower

BY J. E. KINSEY

THE subject of accident prevention in industry is not new. Yet recent surveys indicate that of our country's 200,000 industrial plants, less than 13 per cent have adequate safety programs. The occupational injury rate has been high throughout American industrial history. During the earlier years, relatively little or no attention was given to the conservation of manpower. However, with the formation of large corporations which brought together greater numbers of men and women into one plant, some attention was focused on the increasing human wastage through accidents. Even then, the first reaction was to assist the victims financially after the accident had happened, rather than to stop the accidents which were the cause of their plight. Under the common law system, the injured had very little chance to recover damages. If the employer could prove either contributory negligence on the part of the injured, negligence of a fellow worker, or the assumption of risk by the injured, the employer had no obligation.

WORKMEN'S COMPENSATION LAWS

The realization of the fallacy in such a system brought forth the employer's liability laws. These laws did not establish the burden of proof but only permitted greater ease of recovery when the employer was proved to have been negligent. In 1911 state governments began adopting workmen's compensation laws, and today such laws have been passed in all states except Mississippi. There is wide variation between the laws of the different states, but all of them tend to accomplish the same end:

1. They eliminate negligence as a defense against paying compensation by the employer. The employer pays compensation regardless of the cause of the accident.
2. They provide medical care in order to hasten the return of the worker to his job.
3. They establish a reasonably exact method of computing the monetary benefit to be paid to the injured.
4. They provide benefits at least during a period of readjustment in cases of permanent disability and death; and in some states they provide continued payments to the injured or to the widow and children of the deceased workman.

Workmen's compensation legislation provided the first real stimulus to industrial accident prevention and is primarily responsible for the movement as it was known before Pearl Harbor. The only certain way to avoid paying for accidents is to prevent them.

ACCIDENT PREVENTION AN INVESTMENT

Let us forget momentarily the wartime emergency and deal with accident prevention on a peacetime basis and entirely from the dollar and cents viewpoint. This phase of accident prevention should prove to be of greatest interest to those who are charged with the duties of controlling the finances of industrial concerns; and this discussion may suggest a field for investment which heretofore may have been overlooked. Few individuals would overlook an opportunity to invest their company's money where they were guaranteed a 20 per cent, 15 per cent, or even 10 per cent return, whether it be in their own plant or in the open market. Still there are many who are passing up an opportunity to earn 25 per cent, 50 per cent, 100 per cent, or even more on an investment over which they have complete and unrestricted control.

How does one determine the economics to be derived from accident prevention when considered as an investment?

First. Those in control must be convinced that accidents can be prevented. Upon close examination of the problems at hand, this should not be difficult.

Second. There must be a willingness and readiness to spend money in the same manner as it would be spent for the investment of equipment in the production of the commodities sold by the corporation. These expenditures include not only the cost of guarding machinery and the cost of rearranging physical equipment, but also the payroll expended on safety engineers and the entire line organization in proportion to the time actually spent by these persons on safety and safety training.

Third. It is necessary to establish a reliable method of determining the true and full cost of accidents. It may be a surprise to learn that there are many aspects to establishing the cost of accidents. At first one may think, "This is simple—you merely take the premium paid, deduct the dividend returned (if any), and then you have the net cost," or if self-insured, "Merely add losses paid to cost for the self-insured bond, to clerks' salary for administration, and to a few more items of direct expense, and you have the net cost."

True, this is the exact figure the auditors enter on the books, but it is not the net cost of accidents, and in most plants it is not even 20 per cent of the cost; in many plants it represents less than 10 per cent of the true cost. How then is it possible to determine the true cost of accidents? Space does not permit the full treatment of this subject, but several items of indirect cost may be suggested which should be taken into account in practically all industrial injury accidents. These are taken from H. W. Heinrich's work on industrial accident prevention:

1. Cost of lost time of injured employee.
2. Cost of time lost by other employees who stop work out of curiosity, out of sympathy, to assist injured employee, or for other reasons.
3. Cost of time lost by foreman, supervisors, or other executives in assisting the injured employee, investigating the cause of the accident, arranging for the injured employee's production to be continued by some other employee, selecting, training or breaking in a new employee to replace the injured employee, and preparing state accident reports or attending hearings before the Industrial Accident Commission.
4. The cost of the time spent on the case by first-aid attendant and hospital staff, when not paid for by the insurance carrier.
5. The cost due to injury to the machine, tools, or other property or to the spoilage of material.

6. The incidental cost due to interference with production, failure to fill orders on time, loss of bonuses, payment of forfeits, and other similar causes.

7. The cost to employer under employee welfare and benefit systems.

8. The 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. The cost due to the loss of profits on the injured employee's productivity, and on idle machines.

10. The cost of subsequent injuries that occur in consequence of the excitement or weakened morale due to the original accident.

11. The overhead cost per injured employee—the expense of light, heat, rent, and other such items, which continue while the injured employee is a non-producer.

In addition to all of these points there are others that might well receive consideration, although those items which have been considered here clearly outline the vicious and seemingly endless cycle of events that follow in the train of accidents.

DIVIDENDS FROM ACCIDENT PREVENTION

Returning to the discussion of the idea of investment in safety: if the reader is convinced that accidents can be prevented, if he is willing to spend some money, and if he has learned to measure the true cost of the accidents both direct and indirect, then, and only then, can he be qualified to present his investment idea to top management and demand its fullest support and cooperation. The most vivid proof that investment in accident prevention pays high dividends is illustrated by a few specific examples. The first example may be taken from information developed by the United States Steel Corporation covering the period 1906 to 1938. The figures presented here were included in a letter written to the author a year or so ago by Arthur H. Young, former vice-president of the United States Steel Corporation and now a lecturer in industrial relations at the California Institute of Technology. In order to make the points clear, parts of Mr. Young's letter follow:

"In steel, we had access to a meticulously kept statistical record of many years, which included, in addition to accident frequency and severity rates, a record of all sums spent for safety. This latter included salaries, office and travel expense of regular staff members; time, and other costs of workmen's and foremen's committees; appropriations strictly for safety alone; proportionate costs for safety in appropriations increased over plant needs, when such additional cost was exclusively for safety; plant medical services and hospital costs, etc., about everything the auditors could charge to safety. The total of this, cumulative from 1906 to 1938 inclusive, was $29,595,770. Our frequency data listed every accident causing lost time beyond the turn or tour on which the accident occurred.

"Severity was very crudely tabulated in the earlier years, and to use cumulative figures, I had to continue the original classification. It was a simple division into two classes—'Serious' and 'Non-serious.' 'Serious' included all injuries causing more than 35 days temporary disability, or involving permanent disability to any degree. 'Non-serious' were injuries involving no permanent disability, and less than 35 days temporary disability.

"Each year after 1905 the U. S. Steel Corporation published a statement of 'accidents prevented during the year' in these two classifications. The method of computations was to multiply the average number of employees in each year by the frequency rate for each classification that prevailed in 1905, then subtract the actual number of injuries, the remainder theoretically being the number of injuries prevented by bettered safety practices.

"The number of serious injuries prevented, 1906-1938 inclusive, so computed was 83,392.

"The average cost of compensation and medical service of serious accidents over the period was $612; therefore the theoretical saving was $51,035,904. Similarly, 676,720 non-serious accidents were prevented, and I used a flat $10.00 as a conservative cost of compensation and medical service, or $6,787,200 saving, the total being $57,823,104, or about twice the cost of safety.

"I also discussed with you the cost of labor turnover as influenced by the 83,392 serious accidents prevented, assuming each accident meant replacement of a worker.

"On this, the sky is the limit—I used $100 as a low mean between the two figures, $50 and $200, mentioned in the Hoover 'Waste in Industry' report of several years ago. At $100 per each, there is a by-product valued at $8,339,200.

"In a bulletin of the Department of Commerce dated September, 1930, there is a discussion of many other factors of cost of accidents: idle machinery; distraction of other workmen; loss of time by other workmen giving attention to injured, etc. It surely is a long and complicated (and somewhat theoretical) paper. I asked Harry Schultz to see what he could figure out on the bases therein proposed, while I was still with U. S. Steel. The figures he gave me were so fantastic I never did use them—it looks as if U. S. Steel would have made more money out of safety than it ever did out of making and selling steel!

"And anyhow, the $2.00 for $1.00 in the *valid* statistics is convincing enough. I think, however, one can mention that safety education, which inculcates caution, thoughtfulness, orderly procedure, careful workmanship, and conservation of life must just naturally make better, more precise workmen, interested in the conservation of company property. And that's worth something! Then, too, there is its value as a wholly non-controversial avenue of approach for sound employer-employee relationships."

If these figures sound fantastic, and they are not, others may be examined which will prove the point further.

Shortly after July, 1940, a certain shipyard increased its attention to safety, employed full-time safety engineers and expanded the plant first aid facilities. In the short span of two years, the direct cost of compensation insurance was reduced by 35 per cent. Converted to dollars, this reduction amounts to approximately $14,000 per month based on current payrolls. If it may be admitted that the indirect costs are only double instead of four, five, or 10 times the direct cost, then the corporation is saving $42,000 each and every month through its accident prevention program. The cost of the present program does not exceed one-tenth of this amount. Another shipbuilding corporation is now conducting all California operations at 60 per cent of the direct insurance cost that would have been in order had not this corporation and its executives wisely invested in accident prevention during the past several years.

(*Continued on Page* 14)

the load being carried on these protruding ridges, forming an area roughly 30 per cent of the intended area, the bearing was severely overloaded.

THERMAL EXPANSION

The non-uniform thermal expansion of the lining alloy may constitute an asset, even though the old concept of bearing operation would indicate otherwise. Under conditions in which an ideally smooth surface would only permit the maintenance of an extremely thin oil film, perhaps of molecular dimensions, a wavy and otherwise irregular surface may retain small pools of lubricant sufficient to maintain fluid lubrication to a greater extent. The duplex structure of a bearing alloy may constitute a safety factor rather than an indispensable requirement. In neglecting the benefits derived by non-uniform expansion the engine builder unwittingly sacrifices load carrying capacity. However, the different thermal expansion produces internal stresses within the lining which reduce fatigue life. It is therefore not surprising that modern aircraft engine bearings lined with pure silver have given excellent service, since they were designed with proper clearance and provided with a thin lead coating which lowers the occasional non-fluid friction. In this case the operating temperature is kept down and excessive growth of the lining which decreases clearance is prevented. An excess of growth would throttle down the oil flow, permit rise of temperature and eventual seizure of the shaft.

These phenomena are illustrated in *Fig. No. 7.* Here are two large compressor bearings in which the lining is anchored to the shell by circumferential dovetails. The lining is about twice as thick at the dovetails as at other places. It is clearly impossible to maintain proper clearance in the bearing unless the operating temperature corresponds to that at which the bearing was machined. In operation the temperature was higher and therefore the lining bulged at the dovetails to such an extent that the clearance between journal and bearing was decreased in these circumferential areas. Eventually there was space for only a very thin oil film which carried the whole load, while the spaces between the dovetails acted as wide shallow circumferential grooves. In this case actual seizure of the shaft and outright melting of the babbitt did not occur, because of the plastic flow of the babbitt and comparatively favorable operating conditions.

PRINCIPLES FOR DEVELOPMENT

Once the chain of events has been recognized—duplex structure (or anisotropic metal), uneven expansion, reduced area, overloading, cracking—the inherent limitations of the current bearing alloys become evident and the principles for a rational development of bearing alloys toward longer service appear clear. These principles, the outcome of research at the California Institute of Technology, involve the field of physicochemical analysis in engineering, analogous to previous physicochemical analysis of lubrication.

Accident Prevention

(*Continued from Page* 10)

MANPOWER CONSERVATION

In connection with safety prevention, and keeping the man on the job, recognition of manpower figures which indicate present-day demands are worth reviewing. This information could not be given by any better authority than that of Lawrence A. Appley, executive director of the War Manpower Commission. In the September issue of *Engineering and Science Monthly* he stated that "There are 22,000,000 men between the ages of 18 and 37 inclusive registered by Selective Service Boards. This includes all men regardless of physical, military, or occupational status. Approximately 14,000,000 of these men can meet the physical requirements for military service.

"The armed forces will require 10,800,000 of this 14,000,000 by the end of 1943. That leaves us a balance of *3,200,000. Of this number 1,500,000 will be deferred* for agriculture.

"By simple arithmetic we now have 1,700,000 left for non-agricultural deferment. While that is more than are now occupationally deferred it must be realized that there are many men who have been deferred for dependency who, if they were not so deferred, would be for occupation.

"Before we jump to the conclusion that there are a possible 1,700,000 deferments of able-bodied men for non-agricultural occupations, we must realize that none of the above figures provides for any replacement which will be needed to maintain the armed forces at 10,800,000. That need will be determined by the human cost of the military campaigns that are ahead of us. Neither do they provide for personal hardship cases.

"This manpower arithmetic is another one of the 'dynamic factors' which influence the handling of the manpower problem."

In view of these figures one may ask, "What is industry doing to conserve and preserve manpower in this time of direct need?" It appears that not enough is being done in this direction. One of the most destructive attacks made on this nation last year was not made by a foreign enemy but by accidents. These accidents left 93,000 dead, 350,000 permanently disabled, 9,000,000 lesser casualties, and 450.000,000 man days of lost production. Putting it in a different way, the national economic loss was $5,200,000,000. It cost as many productive man days as would be required to build 72 battleships. All this destruction, this delay, this waste of manpower and materials was caused by accidents. Even though we recognize the seriousness of these figures, accidents are increasing. *Accidental industrial deaths increased five* per cent in 1942 over 1941. Approximately 200,000 more accidental injuries occurred last year than during the preceding year. There was a rise of 10 per cent in the number of man days lost to industry. In 12 states, deaths from occupational accidents showed increases ranging from 25 to 77 per cent.

With millions of employees being shifted into strange new jobs, with other millions of new untrained workers being drawn into plants, working under terrific pressure and at top speed, and with the strains of dislocations of wartime conditions multiplying hazards to life and property throughout the country, the accident toll will continue to increase, and certainly will not decrease until adequate preventive measures are taken.

The fact that off-the-job accidents far exceed the number and severity of occupational accidents must not be overlooked. It might be concluded that industry cannot control or influence off-the-job accidents in view of these figures, but such is not the case, for plants which have reduced work accidents have at the same time greatly reduced off-the-job accidents among their employees. This fact tends to substantiate the claim that accident prevention is mainly accomplished through education, training, and executive order. Therefore, one must accept the axiom that safety is a responsibility of management.

If really good practice in the elimination of preventable accidents is to be reached and held in any establishment, the top management must accept full and definite responsibility and must apply a good share of its attention to the task, just as it does to any other undertaking of vital importance. Every kind of work that men do involves some degree of hazard, and every uncontrolled hazard, if given enough time, will produce its share of injuries. But proper attention to safety will result in the elimination of almost all the injuries that would otherwise occur, regardless of the industry, the type of operation, or the occupation in question. In management is vested all authority, the determination of policies and executive direction; from management must come the drive for safety. Management must want to eliminate injuries badly enough to make accident prevention a vital part of all activities. Prevention must be given continuous attention along with such matters as cost, quality, and production.

Perhaps in time of peace you may treat with accidents as you please, particularly if you are willing to pay the bill. But in time of war, it is your patriotic duty to conserve the only resource for which no substitute can be found—the number one raw material of war—MANPOWER.

Modern Construction in Turkey

(*Continued from Page 4*)

and supplies, asphaltic membranes and hardware (with the exception of nails) are imported from foreign countries.

Labor is cheap compared to material cost. Unskilled labor is abundant and the wages are low. A pick-and-shovel workman, for example, normally earns 60 to 90 cents for an eight-hour day. Of course, one should consider that it is possible for this type of a workman to feed himself for 40 cents a day, but even then his financial life is very modest. Skilled labor is somewhat better off; a carpenter earns from two to four dollars a day. The big jump comes in the earnings of the professional class, such as the engineers and architects. This is primarily due to the great need for such services, and the civil engineer or architect enjoys a distinct position in income and prestige. Strikes and labor disputes of major proportions are practically nonexistent in Turkey. Problems that arise between the workmen and the employer are referred to the "labor inspectors," who see to it that such problems are settled according to the laws and regulations of the republic.

As a result of low labor rates the cost of construction in Turkey is below what it is in the United States. Apartment houses cost from two to three dollars per square foot and the very modern public buildings that are being erected feverishly at the present time cost from four to eight dollars per square foot. The labor cost in the big items such as reinforced concrete, brick masonry, plaster, etc., is about 15 per cent of the material cost. The contractors are naturally very sensitive about any kind of material waste.

Bids for government construction follow a method which has proved successful in this period of intensified construction. The architectural plans are prepared by government offices and a rough material estimate of the future building is made. Then the job is let out for bids. Each bidder receives a set of design, material and workmanship specifications, along with the general architectural drawings. The designing offices of the participating contractors use their own judgment and skill in producing the structural design. The contractors each submit a bid which is based on unit prices. These unit prices when multiplied by the material quantities add up to the total price of the bid. The advantage of this method is that it stimulates the contractors to prepare a design that will be of minimum total cost. As a result of this system the contractors are very conscious of the value of a skillful structural engineer.

LESS LABOR-SAVING EQUIPMENT

Labor-saving mechanical equipment for construction is not used as much as in this country. Concrete mixers and material elevators are usually the only mechanical equipment used in the field. Vibrators, for example, are not used, because it is cheaper to tamp the fresh concrete by hand tools, and the forms are not built sturdily enough to withstand the vibration. Two-inch boards are used under beams and one-inch planks are used for slabs and for sides of beams. All attachment of forms is done by nails.

The building code for reinforced concrete calls for all bars to be provided with hooks. Since plain bars are used exclusively and earthquake forces are expected, this is an inexpensive security measure. As in most European codes the value of shear strength of concrete is neglected once the shear intensity exceeds 40 pounds per square inch. The allowable fiber stresses in concrete are about 25 per cent lower than the values generally used in the United States for ordinary construction. Up to recent years moment factors were used, or, for more exact analysis, the "three-moment equation"; however, the Hardy Cross method of determining moments is becoming more and more popular at the present.

Due to the great demand for technically trained men the government has adopted a very benevolent attitude in employing foreign engineers and architects, and most of these men have done splendid jobs. The foreign engineer, however, has a few problems to consider before making his luxurious salary. The tax rate starts at about 30 per cent withholding and increases as the income gets larger. When leaving the country a person is allowed to take out only one-third of the cash he has made. However, judging by the fact that there are a large number of foreign engineers in the country, these restrictions apparently are not too severe.

The photographs displayed with this article were taken in 1939, and show features of design and construction of the Graduate School of History, Language and Geography, located at Ankara. The author worked on the structural design of this project and was present during the entire period of construction.

Alkylation Plant

(*Continued from Page 8*)

review might be 45 feet long, eight feet high, with possibly three horizontal tiers of dials of various sizes and shapes. At any moment a glance will show what any unit of the equipment, provided with an instrument connection, is doing.

Electric power and light installations in an alkylation plant are extensive. Explosion-proof motors are used in all areas considered hazardous because of the possible presence of hydrocarbon vapors. They might vary in size from ¼ horsepower for driving an exhaust fan to 450 horsepower for furnishing the motive power for a large water pump, synchronous motors being preferred for such units. Electric current is usually brought in several