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OCCUPATIONAL HAZARDS AT BLAST-FURNACE PLANTS
AND ACCIDENT PREVENTION

BASED ON RECORDS OF ACCIDENTS AT BLAST
FURNACES IN PENNSYLVANIA IN 1915

BY

FREDERICK H. WILLCOX

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PREFACE.

The information presented in this report is the outcome of a detailed investigation made at the blast-furnace plants of Pennsylvania during the year 1915 by the inspectors of the department of labor and industry of that State and by F. H. Willcox, metallurgical engineer of the Bureau of Mines. Although accident-prevention methods have been in effect at the majority of plants in the State for a considerable number of years, and although the State department for several years has had its inspectors at the plants to examine plant conditions and to investigate serious accidents, the hazard of blast-furnace work, as indicated by the insurance rates for the workmen, remains among the highest of any of the industries of the State.

It is hoped that this detailed review of the causes, circumstances, and prevention of accidents will be of assistance to the executive officials of the plants and to the employees by making clear the responsibility for accidents, by emphasizing the probability of repetition of many accidents unless care is taken, and by demonstrating the practicability of safeguards, thus resulting in a lessened number of injuries and fatalities.

Though effort has been made to reduce the report to a minimum, it still is large, and there is considerable repetition of discussion of many types of accident as they occur at different places in the plant. However, such repetition has been retained in the belief that it will serve to emphasize the importance of attention to accidents that occur repeatedly and contribute the greater share of the charges for disability and compensation.

Van. H. Manning,
Director.
OCCUPATIONAL HAZARDS AT BLAST-FURNACE PLANTS AND ACCIDENT PREVENTION.

By Frederick H. Willcox.

INTRODUCTION.

In the past the blast-furnace industry was under the stigma of being one of the most prolific sources of killed or seriously injured and permanently disabled workmen of any of the industries of the country. In the popular mind, labor at blast furnaces was little less hazardous than mining, powder making, or railroad work. This impression was based not so much on definite knowledge of the number actually injured and the causes of injury as on the spectacular nature of the accidents that from time to time were described in the press. As with a mine disaster or a railroad wreck so with many furnace accidents, the number fatally injured in such accidents constitutes only a minor proportion of the workmen who suffer more or less serious injuries. However, the reader of the daily paper receives a distinct impression of frightful and sudden disaster which is apt to be associated henceforth in his mind with work at blast furnaces. It is true that in the past this impression has not been without warrant, for from the time of the advent of Mesabi ores, taller furnaces, and faster smelting, which began in the early nineties, the newspapers have chronicled a large number of blast-furnace disasters.

Blast-furnace men have never assumed to tolerate failures in construction or defective control of furnaces. But the admitted hazards of the work are many, and the slow development of improvements in the construction and control of the furnace and its auxiliaries have occasionally given rise to a tendency to accept as a part of the day's work not only the unforeseen and difficulty controlled accidents but accidents whose recurrence might be stopped by the adoption of suitable preventive measures.
In the smelting of iron, even more than in many other industries, safety is inseparably related to efficiency in production, and the accidents strictly incident to work about the furnace are proportional in some degree to the success with which obstacles to smooth working are overcome. This relation does not hold, however, in regard to such accidents as are incident to hand labor, falls, falling and flying objects, machinery, and the use of hand tools.

ACKNOWLEDGMENTS.

The author desires to express his obligation to the officials of furnace plants in the State of Pennsylvania for their hearty cooperation while the field work of the investigation was in progress and to the many furnace men and safety inspectors at the plants for their free and helpful discussions of plant difficulties and hazards and the methods of meeting them.

DEVELOPMENT OF THE MODERN BLAST-FURNACE PLANT.

For a considerable number of years the all-important aim of furnace operators was tonnage. The reasons for centering attention on large output need not be discussed. Immense ore supplies, enormous prospective demand for iron, the cost of labor, and the economies to be effected by working on a large scale were probably the controlling motives. In justification of their views, blast-furnace operators can point to the high degree of efficiency developed at furnace plants as regards application of power, the utilization of the machinery, and the high output per man employed. This development, however, was not well synchronized; it required faster work with novel and dangerous equipment, the handling of increasingly larger quantities of bulky material and of product, the handling of the latter being peculiarly difficult, and was accompanied by a change in the character of the labor supply. Difficulties in furnace operation were increased by the necessity of using larger and larger quantities of increasingly leaner Mesabi ores.

RESULTS OF SEEKING HIGH TONNAGE.

As a result of the demand for tonnage and lower smelting costs, furnace shells were built increasingly higher and of larger capacity and linings were made thicker to give longer service, but some details of furnace design received inadequate attention; the general construction of the furnace was not always such as to conduct to security. A conservative statement would be that the mechanical engineer had usurped the place of the furnace engineer and had developed the furnace with little appreciation of the duty that was to be required of it.
The use of Mesabi ores had shown that mixtures containing them would produce frequent slips violent enough to blow off the furnace top. Instead of providing tops of sufficient strength to withstand the pressures generated by a slip, reliance was placed in explosion doors to relieve the pressure developed by the slip. Inasmuch as increasing the height of stack had led to larger tonnage with an attendant decreased coke consumption, the natural trend of design was to build higher and higher shells until an extreme of 110 feet was reached. The lining of the shell was increased in thickness to a maximum of 6 feet in order that the furnace might be driven hard for maximum tonnage without frequent and annoying delays for relining.

A very large furnace, driven with a tremendous volume of blast, having been evolved, it was found that design and capacity had for the time being gone beyond the limit of control of the furnace operators. The increased height of the furnaces and the finer ores used led to slips of undreamed-of violence, to showers of red-hot burden from the explosion doors, and to blown-off tops. The channeling effects and the pressure of the blast and the irregular working consequent on slipping rapidly wore out the lining. Moreover, there was a determination to work the lining to destruction and a disinclination to go out of blast until the point of absolute failure had been reached, because of the cost of relining and the time required for it. Consequently linings were allowed to become badly eroded, so that scaffolding and severe bosh slips resulted. As the brickwork of some boshes was insufficiently tied in and was weakly banded, occasional bosh failures became features of practice, and as the design, cooling capacity, strength, and brickwork of the hearth in many furnaces were inadequate and faulty, breakout was not infrequent.

These conditions are now a matter of history, but their discussion is necessary to an appreciation of the contrast between the furnace of 1895 and that of 1915. Far from being an indictment of the men who engineered the development, this discussion is rather a statement of the handicaps they overcame. The past 20 years has covered a period necessary to development. Furnace men to-day reviewing that development have not infrequently stated that during those days a strict application of “safety first” to design and construction would not have resulted in as rapid advancement nor in the present degree of security.

Progress and courage in design, based on the practice since 1895, have to-day resulted in furnaces with closed tops strong enough to withstand the pressure from any slip. There are still many furnaces in which there is danger from slips, but the danger is being much lessened by more regular driving and better adaptation of design to
the ores, coke, and blast temperature used. Linings are made much thinner and are not used to destruction, although some thick-lined furnaces remain in blast, and there is a disposition to use them in spite of the danger of failure, because of the time and expense required for relining. Bosh breakouts have become extremely rare—practically unheard of—thanks to additional strength and reinforcement at each relining and in each new furnace. Hearth breakouts also have become rare, owing to better construction and more ample cooling, but occur at infrequent intervals, and seemingly will persist because of the peculiarly combined effects of blast erosion, the chemical attack of slag and iron, and the pressure of the liquid iron on the brickwork. In conceding and emphasizing the splendid progress in design and strength which in modern blast-furnace plants obviates most of the causes of the accidents that have given the industry a bad name, one should remember that the influence of extreme tonnage demands remains and that furnaces of antiquated design, though doing efficient work, are contributing a certain proportion of accidents that are absent in newer and stronger types.

**ADVANCES IN BLAST-FURNACE PRACTICE.**

As the disadvantages of hard driving became evident to the men in charge of plants that were using higher proportions of Mesabi ores each year, and as the greater regularity and the economy in fuel and in lining from easier driving became apparent, there was a swing at many plants to extremely moderate driving—"slow driving." This tendency was accelerated by the let-up in production in 1907, by the great increase in productive capacity of the country, and by the larger output of basic iron, it being more difficult to produce good basic iron than good iron of higher silicon content in a furnace working irregularly, because of slips. Contemporaneously, there came the possibility of using a hotter blast, because of the smaller volume of blast with slow driving and the use of cleaned gas for the stoves.

The result of this change in practice in many plants was renewed heavy slipping, scaffolding, and other irregularities of operation, because the lines of practically all stacks were unsuited to the use of higher heat, or because this higher heat was unsuited to the type of slag that had been made, or because lines, slag, coke, and heat were all unsuited to each other. Also, the volume of the blast was so reduced that it failed to penetrate the burden thoroughly, but worked along the walls, causing erosion of the lining and insufficient reduction of iron. About the same time other difficulties were introduced by attempts to use by-product coke. In short, the attempts at new practice gave rise to almost as much irregularity in operation as
former practice had caused, so that furnace accidents persisted to an extent that was lessened only by improvement in construction.

Within the period 1910–1915 much definitely satisfactory progress was made in obtaining the type of practice sought since 1907–8, namely, the use of high heat and moderate driving. The results may be described as moderately fast driving, the use of moderately high heat, radical changes in stack lines, and the production of a less limy slag. A corollary of this advancement has been a marked decrease of the accidents peculiarly due to slips and other irregularities of operation. Probably quite as much significance attaches to improvement in practice as to betterment in the mechanical design of the furnace.

APPLICATION OF POWER AND HANDLING MACHINERY.

With the increase in the capacity of furnaces there was need of more adequate methods of handling ore, coke, and limestone, and of disposing of iron and slag. A plant operating four furnaces requires each year about 1,000,000 tons of ore all of which has to be unloaded inside of 120 shipping days, so that, if old methods were used, an average of 170 cars would have to be unloaded by hand every day. Such a task was not easy when the number of loaded cars averaged the same each day, and was rendered extremely difficult by the occasional slackening of shipments for a couple of days, the resulting rush, and the congestion of cars. The labor supply was frequently wholly inadequate for taking care of such situations, particularly as some of the men were never sure of employment from day to day, to say nothing of employment in winter, and were constantly shifting to other work.

The development of the mechanical car dumper was necessary to keep the furnace running, and characteristically this appeared at an opportune time to compensate for a diminishing and unsatisfactory labor supply. The earlier development of the ore bridge or crane was due to somewhat similar causes—the impossibility of handling and stocking a high pile of ore in a restricted space and the difficulties in getting the ore from the stock pile to the bottom of the furnace by barrows or by steam cranes. Bins for the ore were introduced about 60 years ago. The larry car, operating on top of the bins, was a logical sequence to the bridge, for it facilitated the transfer of ore from the dumper to the pile or from the pile to the bins without consuming the time of the ore bridge in runs up and down the trestle to get from the stock pile ore of the grade desired in the bin, which frequently is some distance from the pile. In the stock house, a similar car, equipped with scales, was a natural development, as it replaced 12 or more men pushing barrows from the bins to the foot of an elevator. To enable a small crew to get stock from the
bins, mechanically operated bin doors and feeders were installed. The substitution of skip inclines, mechanically operated furnace bells, and automatic dumping was the last step in reducing hand labor in moving the ore, and permitted the number of laborers to be reduced more than 75 per cent. But with fewer minor injuries because of this cutting down of the laboring force came the hazards incident to using somewhat intricate handling machinery, designed primarily for power and capacity and with minor regard to safety, operated at high speed, and hurriedly repaired in case of a breakdown. Moreover, this machinery used electric current obtained from trolley wires or third rails, in some places inadequately guarded and often placed with too little regard for inaccessibility from accidental or careless contact.

As the coke and the limestone, as well as some of the iron-bearing by-products were unloaded on the trestle by hand, some of the men were subjected to the risk of being hit by material dropping from the ore bridge, or of being struck by the larry car running up and down along the bins, as well as to the added hazards of operating and oiling the machinery and those peculiar to hurry-up repair jobs that were frequent because the machinery was not perfectly developed.

Progress in the blowing and power equipment and water-supply pumps had to keep pace with tonnage demands, but was attended with fewer accidents than was the development of other equipment. One reason was that similar machinery was being developed in other industries and was better standardized than ore-handling equipment; another reason was that the workmen operating such machinery were more skillful and intelligent. A new appliance, the gas engine, added to the complication of handling the gas.

The cast house with its beds of chills or molds proved expensive and inadequate for handling large outputs. The invention of the pig-casting machine and, at steel plants, the carrying of the molten metal in track ladles to the mixer eliminated the casting beds. Trap ladles were also introduced to remove the molten cinder instead of running it on cooling beds and then forking it into cars, or the cinder was run into a granulating pit and then removed with a crane.

The place of least change has been immediately about the blast furnace where the hand tools of the seventies and the same hard and trying work are still evident, but invention and better practice have obviated many of the severe tasks and dangerous risks. Steam, air, or electric drills, electric and oxygen burners, cast-iron skimmers, and clay guns are among the outstanding improvements about the furnace. Improvements in the stoves have little effect in complicating operation, as the improvement has been in size and in lining, but the gas-main system with its growing intricacy of washing equipment and of connections has demanded adequate control and skilled super-
vision, especially on stops, blowing in, or blowing out. A patented method of applying steam to gas systems has, however, lessened the hazard of explosions in such systems.

**CHANGING CHARACTER OF LABOR.**

The development of mechanical appliances and the essentially dirty, hot, and rough nature of much of the work have caused a change in the character of the laborers at blast-furnace plants. For 30 years, in all but a few localities, American-born workmen have steadily decreased. The predominating nationality has changed from time to time, but laborers from the most recent immigration have always been the predominating element at blast furnaces. The increasing use of machinery requires more skilled workmen, but ordinary laborers must still do hard, rough work, such as handling material, shoveling, and pushing wheelbarrows.

Labor of the next higher order is needed for such work as cleaning stoves, cleaning iron ladles, dumping cinder ladles, working about the pig machine, and cleaning and making up iron runners and cinder runners. By "making up" runners is meant claying, grouting, or sanding the cleaned runner preparatory to the next cast, adjusting the gates, and warming cold or wet spots. From these jobs men are promoted to more responsible duties. They become stove tenders, keepers, or water tenders; are put in charge of the simpler machinery, such as pig machines or charging cars; oil and wipe in the engine room; or work in the millwright, rigging, or pipe-fitting gangs.

All of these jobs involve laborious, fast, hot, or hazardous work; much of it, in the opinion of many operators, demands men of stolid and phlegmatic nature who can be easily controlled by shift foremen, and accept hard or trying work without protest.

In the past a man who was temporarily disabled by an accident usually had to accept his loss of time and income with no recompense from his employer or the State. Although this condition existed in practically all industries, it bore more heavily on furnace men than on those in many other occupations, because of the greater hazards at blast-furnace plants.

Other factors tending to discourage more intelligent men from taking up blast-furnace work have been the prevalence of the seven-day week, which is more characteristic of blast-furnace plants than of other iron and steel operations; the low wages, the average wage being lower than in any other branch of the industry; and the fluctuating production. The last involved the certainty that at recurrent periods the bulk of the furnace force, except the most skilled, would be out of work or would have to accept jobs with diminished pay.
It is a matter of record that the working conditions mentioned have been unattractive to American-born workmen, and as conditions improved and as immigrants from the British Isles and Germany decreased, the operators were forced to employ other men. As the number of Poles, Slavs, Italians, Magyars, and men from the Balkan States entering the labor gang and working up into the furnace and other crews increased, both the older hands and recent immigrants from northern Europe declined to seek employment among them. This racial antagonism worked in other ways; strikes by employees sometimes caused a complete change in the character of the force, English-speaking stockhouse men, riggers, and crane runners being replaced by men from southern Europe.

One result of such changes in the character of the labor has been to make accident prevention more difficult. Only 5 to 10 per cent of the immigrants from southern and southeastern Europe have come from manufacturing industries, as against 40 per cent of the earlier immigrants. About 70 per cent of the recent immigrants were farmers. Their speech includes many different languages or dialects of the same language, and they may be so divided by racial antipathy as to lose common interest and fellow feeling. Frequently 50 per cent can not speak English, though they commonly understand a few terms used in directing the work.

SIGNIFICANCE OF PRESENT TYPE OF BLAST-FURNACE LABORERS.

Thus instruction by signs and books of rules becomes most difficult, and it is always questionable whether workmen understand each other or the instructions of their foremen. It may happen that they fail to heed a cry of warning when quick action is needed to escape some sudden danger, particularly when the danger is obscure or not self-evident. This language handicap of the new men, their unfamiliarity with the dangers, their ignorance of the equipment with which they must work, coupled possibly with less alertness, render them peculiarly liable to injury.

It is only to be expected, therefore, that a large number of accidents will result from employing such men in work involving the moving of large quantities of material, the handling of great volumes of poisonous and explosive gases, the use of blast at high temperatures and pressures, the pouring of fluid iron and cinder, and the operation of novel machinery.

GENERAL CHARACTER OF BLAST-FURNACE ACCIDENTS.

As is pointed out on later pages, most of the accidents discussed in this report did not result from some exceptional disaster, such as a slip, breakout, or explosion, but arose from a variety of causes
which, except for hot-metal and cinder burns, are found in operations not essentially typical of blast-furnace work, although of necessity connected with it. The difficulty introduced by the employment of men from southern Europe is not essentially different from that in other industries in which rough unskilled labor is usually done by such men.

Thus the subject of accident prevention about blast-furnace plants is not as unique as many persons have believed it to be. Because of the complexity of the smelting process there is great possibility of danger to many men should one man ignorantly blunder or be neglectful in performing his duties. Consequently the rarity of disastrous accidents attributable to the fault of the furnace force speaks much for the skill, intelligence, and resourcefulness of the men who comprise that force, drawn, as they are, from material seemingly so unpromising. It suggests that the members of that same force can acquaint themselves with and protect themselves against the hazards of their work. In any occupation a man assumes more or less risk, and in working at a blast furnace he assumes a risk that is rated by insurance companies as among the highest. Whether the risk at the place where a man is employed about the furnace is small or great, he should know of it and be able to take special care to avoid it.

Even though he is compensated for injuries lasting more than 14 days, the burden of financial loss falls chiefly on the workman, for the majority of accidents cause a loss of time less than the minimum compensation period, and consequently a complete loss of wages. No blast furnace can run without making some offgrade iron; similarly, accidents must be expected. However, there is no more necessity for an accident rate of 250 per 1,000 men than there is for a production of 25 per cent of offgrade iron, and the inherent risks are great enough without the workmen being ignorant of the nature and causes of the common accidents.

Practically every accident about a furnace is a repetition of a similar accident at the same plant or at other plants. A large proportion of these accidents can be avoided by the exercise of ordinary skill and prudence, provided the men are thoroughly acquainted with the causes of the accidents and the hazards of their occupation. A smaller proportion of blast-furnace accidents occur through the fault of the employer, being due to lack of safeguards, deficient equipment, and failure to give proper instructions, but even in these accidents many injuries may be avoided by pointing out the hazards and insisting on carefulness. Many accidents are ascribable to the trade risk, but a knowledge of their character enables workmen to anticipate in some degree the possibility of such accidents and to exercise a greater control over their occurrence.
REVIEW OF BLAST-FURNACE ACCIDENTS IN PENNSYLVANIA
IN 1915.

To afford information, accidents during 1915 at blast-furnace plants in Pennsylvania are comprehensively discussed in the section following; mention is also made of characteristic but rarer accidents not brought out by this review. The discussion should show each man, as well as the employer, the causes responsible for accidents in his occupation. On the theory that what has happened shows what may happen or will happen, the value of this report should lie largely in the remedial action suggested. To increase the value of the report the preventive measures used by various companies in the State are mentioned.

In the review following the accidents have been classified according to the place in the plant where they occurred. They have been further subdivided according to causes.

In the descriptions of accidents the seriousness of the injuries is designated by letters, as follows:
A. Injury resulting in death.
B. Injury causing disability of more than 30 days.
C. Injury causing disability of more than 14 days and less than 31 days.
D. Injury causing disability of more than 2 days and less than 15 days.

CAR DUMPER AND TRANSFER CAR.

The hazards at this equipment consist chiefly of injury from the mechanism of the dumper, from railroad equipment, and of those injuries that are encountered in hand labor and where hand tools are used.

CAR-DUMPER MECHANISM.

The injuries caused by car-dumper mechanism are mostly encountered in stepping on or off the car-dumper cradle while it is in motion. Examples follow:

1. Card boy, after removing card from car, jumped from the cradle after the operator had started hoisting and was thrown from framework of sumper. D.

2. Brakeman stepped on cradle while it was still going down, to climb on Empty car. He slipped, fell, and was caught beneath the down-moving cradle. C.
RAILROAD EQUIPMENT.

Railroad equipment at car dumpers causes serious injuries, as is shown by the following examples.

1. Car rider was dropping car down incline from dumper; brake did not work, and man was thrown beneath car when it struck the empties. A.

2. Temporary car-dumper man was standing at cradle to adjust coupler on empty, when a new car was pushed up on cradle, knocking man down and running over his body. A.

3. Laborer was cleaning track at car dumper when transfer car struck him, amputating arm. A.

4. Laborer was in car cleaning ore out when empty from dumper struck car, causing man to fall through door. D.

5. Brakeman jumped from moving car he was dropping from dumper and fell beneath trucks. A.

INJURIES IN HAND LABOR.

The majority of injuries are to be found in hand labor and allied occupations. The seriousness of the injuries is, however, relatively slight, as compared with those received from railroad and car-dumper equipment, as the following examples show.

1. Laborer was standing on plank over larry bin and barring sticky ore from bin into larry car. Slide of ore caught bar, threw him off balance, and he fell into chute. B.

2. Laborer turned ankle in stepping on rail. D.

3. End door of car fell on laborer's foot. D.

4. While men were throwing ore cleanings from one car to another, man passed between cars and was struck on foot by lump of ore. C.

5. Infection of eye due to neglect to have dust removed. D.

6. Laborer allowed tie to drop from his hands onto his foot. B.

7. Laborer jammed fingers between jack and third rail. D.

8. Laborer struck foot with pick. D.

9. Laborer was cleaning ore from car while it was held inverted on cradle; lump fell from car onto his knee. C.

10. Lineman was repairing electric switch; screw driver slipped and caused electric flash by short-circuiting switch poles. D.

Regarding accident 10, work on a switch should not be undertaken until the fuses are removed from the lines and the switch is dead. In addition the screw driver should be kept wound with adhesive tape down to the bit, in order to prevent short circuits should the tool slip when used on uninsulated switches.

A little less than half the men injured about the car dumper had been employed there less than six months, and ignorance of the hazard of the work and lack of skill may have been responsible for the injuries to these members of the force. As will appear repeatedly, however, and as indicated here, the relative number of experienced and inexperienced men injured does not show that with hand labor and hand tools familiarity with the work offers any pronounced
likelihood of fewer injuries. As will become evident, personal caution and skill, which will be acquired under supervision in six months almost as well as in six years without supervision for their development, are requisite for preventing these accidents.

For men employed about the dumper and as car riders, the advantage of experience is more marked. Barring ore in bins requires some experience or special instruction to avoid getting hurt when the bar is caught in a slide of ore. More care is needed in selecting men to drop cars from car dumpers and in work about dumper cradles. If men accustomed to railroading can not be employed, then those selected for the work should be able to size up a dangerous situation quickly and to take the steps necessary to avoid injury, and also should be able to acquire the skill necessary for work about moving cars.

Getting on and off car-dumper cradles while they are in motion is usually forbidden, but is often practiced by employees and ignored by foremen, especially when work is rushed to avoid demurrage charges on cars. The accidents described show the danger of the practice, and also the danger in making a rule and then allowing it to become a dead letter, thereby bringing other rules into disrepute or at least tempting employees to disregard them at their discretion. To warn men whose duties take them on the dumper cradle out of sight of the dumper operator, some plants place a gong in a convenient place, by which the operator may be signaled when the man is clear of danger. The men concerned are commonly the car boy, the brakeman who “sprags” the car, or the brakeman who adjusts the couplings. The cradle is not operated nor are cars brought on the dumper until the operator knows that the men are out of danger. Work about railroad equipment is admittedly hazardous and when coupled with the operation of a car dumper may become more so than usual.

In cleaning cars after they are dumped there are two practices: (1) The cars are cleaned while in the dumper and inverted over the larry-car bin. To accomplish this most safely, a substantial platform with railings and high toeboard toward the dumper is recommended. A variation of this method is to clean the cars from the cradle itself, while it is tipped over the ore yard, but this method subjects the men to the danger of falling lumps of ore and in “rush” work, the operator is apt to start the cradle back before the men are off, the car cleaners stepping from the cradle to the cab platform while the cradle is tilting back. (2) A better plan, if the dumper operates along stock-yard walls, is to clean the cars after they leave the dumper. If the yard is large enough for spur tracks, the cleaning should be done on the spur after it is filled, no empties being allowed to bump into the cars being cleaned. If only one track leads from the dumper, the car
cleaners should never work in the first six cars next to the dumper, and the farther back they work the better, as they are warned by the noise of the first bump to hold tight before the shock reaches the car they are in. The brake of the last one or two cars of the string should be set up to retard the kick. If men are available, it is better to shovel the ore over the side of the car, rather than to open the drop doors, the shoveler thus being safe from falling through the doors and possibly being run over. Ample side clearance should be provided for car riders to jump from moving cars, and enough men should be provided so as not to require one man to adjust the coupler and to "sprag" the cars.

Ore transfer cars should be provided with an effective warning signal. Electric horns have been used, but they do not appear to be as effective as anticipated, because their sound is obscured by mill noises more than is a whistle. A 2-inch air whistle with a distinctive sound is probably the most effective warning. Gongs are not especially suitable for transfer-car service. Fenders that will lift a man from the rails and push him aside should also be provided at both ends of a larry or transfer car. There is pronounced need for the design of improved fenders for larry-car equipment, as practically all in use are more likely to mangle the man struck than to ward him off.

A car dumper with a guarded platform at the hopper and at the sheave wheels is shown in Plate I, A.

ORE YARD AND ORE-BRIDGE CRANE.

The hazard encountered at the ore yard and the ore bridge lies largely in the operation, maintenance, and repair of the electrical and mechanical equipment.

1. Employee was descending ladder on leg of ore bridge when adjacent bridge bumped into it, catching man between two cranes. B.

2. Electrician making repairs to hoist motor kept hand on shaft when signaling operator to hoist, and hand was drawn into mechanism. B.

3. Ore-bridge operator was turning down grease cup on hoist while it was in operation and sheave wheel caught glove, drawing arm into mechanism. B.

4. Millwright was making hitch when craneman raised a little on hoist, catching finger. B.

5. Laborer attempted to dislodge a lump of ore from the jaws of a bucket, when the jaws closed, crushing hand. B.

6. Transfer-car man was attempting to straighten up ball attached to ore bucket when the ball fell onto legs. B.

7. Hooker-on, attaching hook to ore bucket, kept hand on bail as bucket was raised, and caught hand between bail and bail of adjacent bucket. D.

8. Ore-bridge oiler pulled electric switch and received electric flash in eyes. D.

9. Electric repair man in putting in fuse caused short circuit, and flash burned eyes. D.
10. Craneman threw switch, causing fuse to blow out, burning hand. D.
11. Craneman connecting wire for electric light caused short circuit, burning hand. C.
12. Rigger was taking strut from bridge with crane. The strut swung and knocked man’s leg against rail girder, amputating leg. B.
13. Laborer was in car in which grab bucket was scooping ore. Operator did not see man and hit him on head in lowering the bucket. D.
14. Trestle man was sitting on side of car directing unloading of car with grab bucket, when bucket swung against leg. C.

When work is being done on cranes or runways where other cranes are running, the idle crane should be protected by track torpedoes placed 25 to 75 feet away, depending upon the effectiveness of the brakes. An ore bridge equipped with safeguards is shown in Plate I, B.

The electrical accidents emphasize the need of safety-switch boxes which will prevent flashes from burning the operator when the switch is operated. Fuses should be similarly inclosed or placed so far away from the switch that the flame or flash from the fuse blowing can not injure the operator. For replacing fuse plugs, fiber or other insulated tongs should be provided. It is probably well to insist that the work of installing lights or making connections to electric circuits be done by electricians, as the work is apt to prove hazardous to inexperienced men, although not difficult or dangerous in the least for skilled workmen.

The other accidents disclose a variety of unsafe practices. It is almost a certainty that men who persist in oiling machinery in motion will eventually suffer accident. As regards ore-bridge cranes, at least, there is no necessity for such practice. When practicable to do so, the switch controlling the motor should be thrown open and locked whenever the crane hoist or trolley does not require occasional movements to bring parts under repair within reach. When such movement is necessary, men capable of the duties of electrician or millwright obviously should know enough to get into a safe place before giving any signal for operation that will place themselves in jeopardy. Crane operators should not hoist until the hooker-on has given a signal to do so, and, just as important, the hooker-on should not keep his hand between a chain, cable, or hook and the object to be hoisted after giving the hoisting signal, nor between the material to be hoisted and any object between which he may be caught when the load swings. The signal to hoist should always be given by the hooker-on. These are elementary precautions, and self-evident, but they are repeatedly and persistently ignored in the operation of cranes.

The last two accidents serve to indicate the need of enforcement of practices that will prevent men from remaining inside cars in which ore grab buckets are being used. When it is necessary for men to
A. CAR DUMPER WITH GUARDED PLATFORM AT HOPPER AND AT SHEAVE WHEELS.

B. ORE BRIDGE EQUIPPED WITH SAFEGUARDS.
A, Guard for wheels; B, device for clamping bridge to rails; C, guard for driving gears.
get inside to shovel up the ore for scooping, the crane operator should not lower the bucket until the men are out of the car, or at least in the opposite end of the car from where the bucket is to be lowered. In using hoist tackle in removing and replacing heavy objects there is the same danger of a side swing, and strong guy lines should be used to retard the swing and to control the path of the hoist, and the men in whose hands the guy line is placed should take a wrap or turn of the line about some convenient strong object.

The other accidents are illustrative of the lack of thought of either the foremen in not warning men of unsafe practices or of men in disregarding the self-evident dangers of work with this equipment; they show the need of teaching caution even to men who may have come through some years of experience without serious injury, some of the injured having had as much as 10 years' experience.

FALLING AND FLYING MATERIAL, FALLS OF WORKERS, AND MISCELLANEOUS ACCIDENTS.

1. Laborer was unloading ore from stock pile into buggy when ore rolled down pile onto leg. D.
2. Laborer was breaking lump of ore when piece flew and struck hand. D.
3. Laborer got in way of stone breaker, and was hit on hand with sledge. D.
4. Craneman was cutting hand leather from scrap belting and knife slipped and cut him. D.
5. Repair man missed his grip on rung of ladder while climbing up leg of ore bridge and fell about 20 feet to track rail. B.
6. Oilier of ore bridge, in coming down ice-coated ladder of ore bridge, slipped and fell about 18 feet onto girder of ore bin. B.

Accidents like the last two, which resulted because of a lack of a safety cage, must be attributed to the negligence of the company, as safety cages have been for some years standard equipment on all ladders more than 10 feet high. On the recently erected ore bridges steps rather than ladders are used.

Slivers and fragments flying from ore or limestone being broken with sledges have more than once caused loss of eyesight, and as flying material is to be expected in such work, the men assigned this work should be given goggles and compelled to wear them. There is no such handicap in their use as at times occurs in cast houses and at pig machines because of the presence of steam.

A hazard that exists where men haul ore from the stockyard to the furnace is the danger of undercutting a pile of frozen ore and having the pile collapse and bury the workmen. Foremen should exercise close supervision of the work where charging is still done in this way.

The accident caused by the knife slipping while a man was cutting a hand leather is trivial, but could easily have been serious. When
safety hand leathers are furnished, as is done by a large number of companies, they eliminate a variety of hazards incident to the preparation and use of hand leathers from scrap belting or leather.

**TRESTLES.**

Flying material, falls, hand labor and hand tools, and railroad equipment comprises the outstanding causes of injuries on ore trestles.

**FALLS.**

1. Carpenter tripped on loose board in walk and fell to yard. D.
2. Stock unloader, in climbing out of car, slipped and fell. D.
3. Ladle chaser fell from trestle walk to yard, 18 feet, fracturing arm and leg. B.
4. Laborer standing on ore in car was carried into bottom of car when ore collapsed. D.
5. Car unloader was standing on plank along trestle unloading car when plank overturned, causing fall. B.
6. Bin feeder was barring ore in bin when slide of ore caught bar, throwing man into bin. D.
7. Laborer stumbled over coke fork and fell into coke bin. C.
8. Bin man stumbled over loose plank in trestle walk and fell into bin. D.
9. Stock unloader was jumping from rail to rail over trestle bin and slipped, cutting leg on rail. D.
10. Rigger was standing on ore in bin when ore was drawn in the stock house from bin; collapse of footing caused him to be carried down in bin. D.
11. Laborer was standing on ore in car, barring ore through doors, when ore fell in, carrying man into ore bin, causing internal injuries. C.

Although none of the accidents in this classification resulted fatally, there have been in previous years several instances in which similar accidents resulted fatally. Men should not be allowed to get on top of carloads of material before the drop doors are opened. When men must enter a car to unload it, they should be warned to keep away from the edge of the ore toward the drop door, as the ore may slip.

Belts and safety lines are provided at many plants for work in cars where the ore is likely to slide and carry the men through the doors into deep bins or when the trestle is high above the ore pile. Similar devices should be used when it is necessary for a man to enter bins to clean them out, or when men must work in them regularly to keep the ore moving down to the doors. The use of belts and safety lines is stated to have prevented several serious accidents at a large plant in the Pittsburgh district, where they have saved men from being covered in a slide of ore, or have enabled men carried down in a slide and covered up to be found at once and dug out without delay.

A steel platform at ore-bin chutes that promotes the safety of men filling ore buckets is shown in Plate II, A. A trestle with grating between the walk and the rail girders is shown in Plate II, B.
A. STEEL PLATFORM AT ORE-BIN CHUTES FOR SAFETY OF MEN FILLING ORE BUCKETS.

B. BLAST-FURNACE TRESTLE, SHOWING GRATING BETWEEN WALK AND RAIL GIRDER.
FALLING AND FLYING OBJECTS.

1. Assistant foreman was on car to dislodge lump of ore frozen to side of car; lump fell and struck man, fracturing thigh. B.

2. Ore unloader was in car, standing in bottom, and barring ore down through doors. Lump rolled down from top of pile and struck him on leg. B.

3. Trestle man was passing coke car when bar laid on top of car side fell on head. B.

4. Unloader in coke car had dust blown into eyes. D.

5. Carpenter was tearing down old trestle when the structure collapsed and he was crushed by falling timber. A.

Falling of ore or limestone lumps is the main cause of injuries from falling material. Three other accidents similar to No. 1 and 11 other accidents similar to No. 2 occurred. The most hazardous condition is introduced when the carload is frozen and the ore or stone beneath the frozen crust is cut away. The work is especially dangerous because, in cold weather, foremen and men are apt to be benumbed and to lose their ordinary caution, and, in addition, the work is usually behind, the bins are low, and every consideration urges haste. In order to keep the furnace going chances are taken in unloading, as to stop the furnace at a time when it is working badly or when it is low might introduce a greater hazard than is faced in hurry-up work with frozen ore and flux.

At such times, every aid that will minimize the danger should be employed. The provision of a steam line, with hose and gas-pipe nipples to insert in the ore for four to six hours before the car is spotted on the trestle, is a great aid in unloading and is widely employed where the capacity of the ore yard is insufficient and ore must be shipped through the winter season; dynamiting the top crust and large lumps of frozen material is helpful; where natural gas is available at low rates it is employed with good results; in western Pennsylvania, the practice is common of keeping in touch with the Weather Bureau, and when a cold snap is imminent, shipments are stopped.

In using steam hose, care must be taken that the hose is in good condition, as it is apt to deteriorate under extreme temperature changes.

In using dynamite, only small charges should be used; usually half a stick is sufficient, and for best results the hole in the frozen crust should be at an angle of about 45°. Firing is most safely done with a firing battery, warning being given, and a man being stationed to see that no one comes within range of the flying pieces of ore. Dynamite should always be thawed before using, as the use of frozen dynamite is very dangerous. Standard thawers should be provided for thawing, and no attempt made to thaw the explosive by placing it near a stove or boiler, or in a pail with hot bricks.
Such accidents as No. 2 are to some degree unavoidable. Men standing in supposedly safe positions are sometimes struck by rebounding lumps of material. When it is necessary for men to get down into the car to pull the ore down in the hopper to the doors, the safest place to stand is between the two hopper doors, where there is the least chance of being struck by a lump of ore or by the collapse of the face of the pile.

HAND LABOR OR HAND TOOLS.

1. Two laborers were unloading heavy scrap and one allowed his end to slip. The piece in falling crushed other man's toes. C.
2. Scrap rolled from pile in car onto man's foot. D.
3. Laborer was throwing scrap from car when hand leather caught on rough edge of scrap, wrenching arm. D.
4. Laborer unloading lumber allowed piece to slip, tearing nail from finger. D.
5. Ore unloader was sLEDging bottom of car to make ore slide out of door, and caught wrist on cotter pin of winding rod. D.
6. Laborer strained muscles of abdomen in working with car wrench. D.
7. Laborer ruptured blood vessel in neck in lifting timber. D.
8. Laborer cut hand on rough scrap. D.
9. Laborer allowed lump of ore to drop on foot. D.
10. Unloader was opening door of limestone car, when door opened suddenly, causing wrench to jerk, and threw man into bin where he was covered by limestone from car. A.
11. Stock unloader was holding bar when man sLEDging on it hit him in back. D.
12. Bin man squeezed fingers between bar and ore-bin girder in loosening ore in bin. D.
13. Laborer struck kneecap against end of bar. C.
14. Ore unloader's pick struck shovel lying on cross strut in car, causing it to fall on finger. C.
15. Bin man jammed hand between end of bar and ore-bin girder in withdrawing bar from sticky ore. C.
16. Man placed pinch bar under car wheel to stop car; wheel catching bar threw it up against car frame, jamming hand. D.
17. Trestle man was holding steel wedge being driven in frozen ore, when steel sliver from wedge struck his eye. Loss of sight.
18. Sledge came off handle and struck man on head. C.
19. Coke unloader was beneath car working on warped door while helper was trying to close door; door dropped and hit unloader's back. D.
20. Laborer went beneath car to pry open door, when it opened suddenly, squeezing chest. D.
21. Laborer, in dropping car door, caught palm of hand in cotter pin at end of winding post. C.
22. Laborer scratched elbow and did not report injury, but dressed it with kerosene and tobacco. Infection. C.
23. Laborer pinched finger and did not report for five days. C.
24. Laborer fell from car and scratched palm of hand. Did not report in jury. B.
25. Laborer's hands became blistered. Did not report. D.
The handling of scrap caused many accidents similar to the ones mentioned. Safety hand leathers would have prevented many of them, but a considerable number were caused by one of two men letting go a piece of scrap before the other. The handling of rough scrap is necessary, and such accidents, like most hand-labor accidents, are due primarily to a dulling of carefulness by the continued repetition of uninteresting work and its seemingly little danger. The prevention of such accidents is a difficult problem. Although supervision helps, there are limits to the extent to which it can be carried. The substitution of machinery for hand labor is a more effective means. For instance, one plant handling ladle and runner scrap from six furnaces has almost entirely eliminated accidents from this source by the use of magnets in the cast house and on the trestle.

Many of the types cited illustrate again the necessity of familiarizing everyone with the hazards incident to the use of hand tools and to hand labor. Personal caution by the men and close supervision by foremen must be insisted on if such injuries are to be reduced to the minimum. An inspection committee, an inspector of tools, or a foreman should examine all hand tools once a week to insure that they are in safe condition, to prevent accidents similar to Nos. 17 and 18.

Car wrenches cause many accidents around the trestle. The sudden dropping of doors with a weight of several tons of material on them will sometimes cause the wrench to fly about suddenly and may easily catch the wrench man in an unfavorable position. Twenty-three accidents similar to No. 10 occurred, two being fatal. The manner in which these accidents occur is varied. The man may not be in a position to detach the wrench from the winding post when it turns suddenly, or the motion may be so instantaneous that he has not time to loosen his grip on the handle. Consequently he is thrown against the car or walk or into the bin, or the wrench may fly about entirely, throw the man into its path, and deal a severe blow on his head or body. Sometimes excess of caution in avoiding these injuries leads to harm. Eight injuries were caused by the wrench slipping off the winding bar. The men are, not unnaturally, apprehensive of injury when the car doors are opened and are usually careful to so place the wrench on the winding bar that in event of its turning suddenly the wrench will be thrown off or may be detached easily. As a result of misjudgment in placing the wrench, or because of a rounded winding-bar nut, or a slippery wrench socket, the wrench may slip off the bar and cause the user to fall, or it may fall on his feet or catch his fingers.

Such accidents show the need of using safety car wrenches. These wrenches are already widely used, but some are not literally safe. Five accidents occurred with so-called safety wrenches. As an ex-
ample, a man was opening the car doors with a safety ratchet wrench which failed to work when the doors opened suddenly, the wrench flying around and causing a compound fracture of the great toe, with 42 days’ lost time.

However, safety car wrenches should be used, as there are types that afford security. On no account should square-socket, nonsafety wrenches be used.

RAILROAD EQUIPMENT.

1. Stock unloader was on coke car loosening brake, and when the catch was kicked out the wheel whirled about so violently as to throw man off brake platform onto track. D.

2. Laborer was dropping two empty cars from trestle and could not manage brake. When they bumped the string of empties, he was thrown into car. D.

3. Foreman was dropping cars on trestle when brake would not work. He jumped from car, ran ahead to next car to set brake, and when cars bumped was thrown to rail, wheel passing over toe. C.

4. Brakeman was setting brake on car, and when it bumped was thrown off. D.

5. Stock unloader was caught between two cars. B.

6. Laborer was unloading car when it was bumped by a drag of cars being placed on the trestle. Man was thrown through drop doors to ore pile. D.

7. Laborer was run over and disemboweled by transfer car. A.

8. Laborer was in bin cleaning it when transfer-car doors opened just as it passed over bin, allowing contents to fall on man. D.

9. Stock unloader was spragging car with block of wood and wheel threw block in such a way as to crush finger. D.

10. Transfer-car man was burned by the short-circuiting of the light wire in the cab. D.

Whenever men are working in bins they should be protected by track torpedoes or flags; they should not be allowed to enter bins over which larry cars or ore bridges with loaded buckets are running. In spragging cars, short pieces of lumber should not be used. Whenever cars are spotted on the trestle and the cars previously spotted are removed, the foreman should be sure that all men are out of the cars before the engine or new drag bumps the cars in coupling on or pushing them down the trestle. Cars in which men are working should be protected by a flag placed and removed by the foreman. A larry-car operator is primarily responsible for the safety of men who inadvertently get in the way of the car. Inasmuch as the car runs at irregular intervals, men can not, within reason, be expected to be continuously on the alert for it and do their work effectively. Especially when the car is running with the operator at the rear should he have the car under control and blow the warning whistle frequently, because a clear view of the track can not be had. The possibility of injury through lack of control of cars by reason of deficiency in skill or in the brake itself is evident, and although the
men engaged ranged from skilled to unskilled, it is always better to have men accustomed to the work do these jobs.

MISCELLANEOUS TRESTLE ACCIDENTS.

1. Laborer hung a torch under car while he was working on a car door to get it open. He bumped the torch, causing it to upset and spill burning oil over his arm. D.

2. Laborer opened doors on flue-dust car and hot dust blew out over his feet. D.

From time to time, throughout the entire works, the common torch or "smoke pct" either upsets or explodes when placed on a hot surface, causing more or less serious burns. There are many places where the use of an electric light on an extension cord is not feasible and where the torch seems necessary, but it should be so placed that it will not be struck by tools. Prevention of flue-dust accidents is discussed elsewhere (pp. 62-69).

To conclude the material on trestle accidents, mention may be made of the importance of having the trestle walk sufficiently wide so that men will not be in any danger of falling into the bin when they are thrown off balance by a car-wrench mishap. The walk can extend within 12 inches of the rail-girder. Another safeguard is to have a grid composed of round iron bars between the girder and the walk. (See Pl. II, B.) Each pinch-bar handle should be provided with a steel disk, and the heel should not be allowed to get smooth.

STOCK HOUSE.

1. Helper on larry car jumped off while car was in motion and fell against wall. D.

2. Men in skip hole cleaning up left trapdoor open. Stock-house men walked into open hole, falling into skip pit. D.

3. Larry-car man, standing on top of scale car pulling coke from bin, fell to ground. D.

4. Boiler maker's helper was on temporary scaffold repairing bin chute. Board was insecurely fastened, causing him to fall to floor. B.

5. Boiler maker in repairing bin chute propped bin door open with piece of lumber. Was sitting in chute when prop slipped, letting bin door drop on leg, breaking bones above ankle. B.

6. Boiler maker was repairing ore-bin door when larry-car operator put feed mechanism in gear to draw ore from the bin. Boiler maker was thrown to floor. D.

7. Man placed handles of wheelbarrow on end of larry car and then sat down in barrow. Larry car started, upset the barrow, throwing man out onto track, and ran over him. A.

8. Man was thawing ore in chutes with gas. Turned on gas and attempted to light it with a match, when the gas flared out and burned him. D.

9. Laborer was working under empty bin; hot flue dust was dumped into bin and some escaped from door of bin and fell on him. D.
10. Barrow man was burned by hot sinter dumped into and escaping from door of nearly empty bin from which he was drawing sinter.  
11. Bottom filler stepped into pall of scalding water.  
12. Larry-car helper was throwing switch and was struck by larry car.  
13. Laborer while cleaning tracks was bumped by larry car and thrown to ground.  
14. Man sitting beneath bins with feet toward track slipped from seat as larry car passed.  Foot went beneath wheel and toes were slightly crushed.  
15. Repair man had leg broken when larry bumped idle larry upon which he was working.  
16. Laborer cleaning stock house was struck by scale car and suffered an injured hip.  
17. Clean-up man wheeling scrap to skip pit was caught between two larries.  
18. Helper was cleaning ore from track at skip pit where larry car had just dumped charge.  Operator, not seeing him, started car and caught foot.  
19. Stock-house man was standing on skip car working on larry-car doors, which were stuck.  As car doors opened, car moved and wheel caught man’s fingers, they having been on rill to keep him from falling while on skip-car edge.  
20. As man was shutting limestone chute, lever broke, causing him to lose balance and fall.  
21. Nut on bin-chute mechanism fell on larry-car helper’s head.  
22. Larry-car helper caught hand between side of bin-door chute and door.  
23. Bottom filler, in prying lump from bin chute, had fingers caught by lump when it slid out.  
24. Larry-car helper standing on top of car side was struck on foot by large lump of ore he dislodged from bin door.  
25. Larry-car man in operating limestone-bin door was struck on foot by lump of limestone.  
26. Piece of limestone fell from chute on larry-car man’s head while running car beneath chute.  
27. Laborer was hit on foot by lump from poorly closed bin door.  
28. Barrow man let piece of scantling used to block ore in chute fall on foot.  
29. When scrap was dumped from wall into stock house, piece flew and hit man’s face.  
30. Scrapper, in pulling scrap to scale car, fell when hook slipped off scrap.  
31. Scrapper cut hand on sharp scrap.  
32. As man was throwing scrap into skip car, his glove caught, pulling him down into bucket.  
33. Coke dust flew into man’s eye.  
34. Man let scrap fall on foot.  
35. Helper loading heavy scrap into barrow had flesh on finger scraped to bone when fellow workman shoved the piece before it had cleared the top of barrow.  
36. Scrap man pulled piece of scrap from bottom of pile, when pile tumbled, crushing man’s toes.  
37. Larry-car man’s helper in throwing the switch put foot on lever to force it down, allowing other foot to remain beneath lever, and fractured great toe.  
38. Man loading ore buggy from stock pile let lump fall on foot.
39. Barrow man in pulling barrow struck head against bin.  D.
40. Man holding bar was struck on nose with sledge.  D.
41. Bottom filler pulling buggy slipped and struck knee cap.  C.
42. Helper pulling buggy had foot run over when one wheel struck coke and made buggy swerve.  D.
43. Helper ran buggy wheel over fellow workman’s toe.  C.
44. Helper was pushing barrow when wheel hit lump on floor. Barrow swung, catching hand between handle and post.  D.
45. Buggy was run into another, catching bottom filler’s hand.  B.
46. Barrow man, in pulling off scales buggy in between two others, caught and fractured finger.  B.
47. Barrow man lifted end of barrow to try weight. Helper placed hands on back to push barrow away, when barrow man let end down catching helper’s fingers between top of barrow and bin chute.  B.
48. Barrow was run into helper pushing on another barrow.  D.
49. Man allowed buggy to overbalance backwards, and barrow leg hit shin.  D.
50. Barrow man let barrow leg down on heel.  C.
51. Cager strained himself in moving heavy ore barrow. Did not report for work for 22 days, when he was found to have hernia as result of strain.  B.

Accidents Nos. 1, 2, and 4 illustrate the dangerous practices of getting off cars in motion, failure to guard floor openings, and lack of inspection of scaffolds before use. It should be a part of a foreman’s duties to correct such practices.

No. 3 illustrates a type of accidents of which nine similar accidents occurred, usually when the ore was sticky, lumpy, or frozen. At such times it is necessary for the larry-car men to do this work from the side of the car, standing on the edge of the hopper. They may be in positions where a rush of ore or a lump may hit them. Four accidents of a similar type occurred where men were working alongside of hand barrows. Care must be taken by men to stand away from the path of falling lumps, and whenever headroom permits platforms from which bar men can work should be provided. Some of the older types of bin doors make it necessary for men operating the doors to stand dangerously close to the path of the falling material. These conditions should be remedied.

Accident 5 illustrates the need of close supervision of methods of work that is essential to put work on an absolutely safe basis. Although it is impossible for a foreman to accompany each man to his work and personally supervise him, nevertheless the job, if unusual, should be examined by the foreman and explicit directions given, especially as men unaccustomed to the plant may easily encounter unfamiliar jobs for a considerable period. All bin-door mechanism should be guarded, and if some one is adjusting or oiling some part of it the larry-car operator should be notified so that he can warn those engaged in the work in case it becomes necessary to use the bin.
Accidents 7 and 8 illustrate thoughtlessness, an element that can be eliminated only through a strenuous campaign of education in safe ways of work. Gas should never be lighted at the end of nozzles with a match, as the control of gas flow is uncertain. Burning waste, coke, wood, etc., placed in the chute or on the floor, should be used.

Regarding accidents 9 and 10, before material of any description is dumped into an empty bin, the stock-house force should be notified so that they will be away from the door. Flue dust or flue-dust products should be thoroughly wet before being dumped into the bins.

In each of five accidents in which men were struck by scale cars the cars were equipped with continuously sounding gongs. The danger of such warnings is that the men become used to the continual noise by long association so that it ceases to be effective. The weight of evidence is against a continuously sounding gong. Much better is an emergency signal, preferably a loud whistle, operated by a foot button or lever, as the operator’s hands are fully occupied with the controller and foot brake.

Accidents like Nos. 18 and 19 could, of course, not well be prevented by warning whistles. No. 18 would have been avoided if the helper had set the brake, and No. 19 if the stock-house man had kept out of the way after the car had been dumped.

Most of the accidents in handling scrap, of which there were many more than mentioned, were due to the lack of ordinary care and skill. It is difficult to distinguish between the two, because a man sometimes misjudges the weight or balance of a piece and it turns and slips from his grasp. Such accidents are not the results of carelessness but of error of judgment or of lack of experience.

The considerable number of hand-labor and hand-tool accidents encountered are not reviewed, as they do not differ from others reviewed elsewhere. The significant fact is that long employment gives no immunity from injury to men engaged in these tasks. The variety of tasks they do is almost infinite; few safeguards can be applied, and the obvious need is training.

In handling scrap the safety hand leather is absolutely essential, as is illustrated by accident 32. A safeguard for the handling of scrap being taken to the stock house is an inclosed chute, which prevents the pieces from breaking and flying when dropped.

In regard to buggy accidents, of which accidents 41 to 51 are types, buggies are in use at only two large plants, though several small one-furnace plants have this equipment. One large stock house with this equipment reported no buggy accidents resulting in disability in excess of 7 days, whereas another, equally large, had
several accidents causing disability in excess of 14 days. One plant has intensive personal safety work and the other does not, and therein lies the explanation. The work is perhaps semiskilled, as the ore buggy, loaded, weighs as much as 2,350 pounds. Not a little dexterity is required in balancing, pulling, and dumping it. If a man's hand or foot is caught there is certainty of injury of some degree.

However, accident prevention is a matter of skill and continued care and it is impracticable to particularize as to ways and means of attaining this skill in managing barrows. Foremen in stock houses should be on the lookout for growing carelessness, and should take every opportunity to show new men, as best they can, how to handle the barrows with the least labor and danger to themselves.

Accident 51 is typical of the repeated instances of reluctance of men to report injuries. There were two cases of infection in the stock houses; in one the man did not report his injury for 11 days, and a small scratch became a serious injury. In the other a man abraded the skin of his leg through the cloth of his working clothes, did not report for 5 days, and lost 20 days as a consequence of infection.

The feeling that prompts men to ignore little wounds is their experience that former slight scratches or cuts have not caused trouble. Added to this conviction of immunity is the reluctance to report the injury for fear that it will result in their being ordered to stop work for a few days. Loss of wages may be a serious misfortune to a man earning an average wage about a furnace plant. The experience of more than one large company in the last two years indicates that it is possible to shorten to a marked degree the lost time attendant on minor injuries. Efficient treatment of minor injuries prevents a serious loss of time for those injured, and consequently their reluctance to report their injuries disappears. The reduction of lost time attendant on slight injuries is one of the most important accomplishments to be achieved in getting men interested in safe methods of work.

**SKIP PIT AND HOIST.**

1. Cage being a little above the top platform, top filler started to lower it. Brake was on tight and he had to turn on much steam to start cage; then it dropped 5 feet before he could stop it. As cage at bottom started suddenly, man riding on it jumped off and was hit on head by safety gate. D.

2. Top filler started cage up as man was taking barrow from cage, and the bottom filler was thrown; contusion of head. D.

3. Stock-house man knelt down to open skip-pit siphon valve next to skip incline. Placed hand on skip-car rail and skip passed over hand. C.

4. Millwright was repairing steam insulation on steam line running up skip incline to top of furnace, and was struck by descending skip. C.

5. Motor Inspector was repairing overtravel device and allowed tool to touch contact plates, causing flash. C.

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6. Electrician working on rear of switchboard touched tool against a bus bar, causing burn of wrist. D.

7. Pipe fitter was standing on ladder taking down pipe when pipe wrench slipped, causing ladder to tilt. He jumped and injured side. B.

8. Piece of coke fell from skip, striking laborer on head. D.

9. Man was cutting rivets at skip hoist when one flew and struck laborer standing nearby. D.

10. Laborer was cleaning out skip pit when lump of limestone fell from bucket onto foot. D.

11. Millwright foreman strained back while changing cables on skip counterweight. D.

12. As buggy man was pulling barrow onto cage, the momentum of barrow pushed him against wall. D.

13. As barrow man was pulling buggy onto hoist he lost control of it and was jammed against the side of elevator. B.

14. Laborer in pipe gang was disconnecting pipe from skip-pit siphon when steam was turned on and scalded his legs. C.

15. Stock-house laborer was cleaning up along the stock house when material thrown by a furnace slip struck him. D.

16. Helper was oiling skip-car wheels when hoist man let car down unexpectedly. C.

Accidents similar to Nos. 4 and 16 can be eliminated by locking open the skip-motor switch before working on the skip or the skip incline.

Accidents similar to Nos. 1 and 2 may be avoided by not allowing men to ride on the hoist to and from the furnace top. In so doing they are constantly subject to accident from failure of overtravel devices, cables, and safety clutches, and from falling material. Such a rule, although difficult to enforce, and seemingly impracticable, is adhered to at certain plants. If men are allowed to ride on the hoist there should be provided screens at the sides, a cover over the top, and efficient safety catches. The cables should have especial attention as regards breaking strands and lubrication.

Three other accidents similar to No. 2 occurred and were the result of the custom of having the control of the elevator in the hands of the top filler. It is the rule that the top filler is not to move the cage until the cager at the bottom has signaled him, usually by a gong. As this signal is given hundreds of times a day, it may become so associated with routine that, even when not given, it is believed to have been sounded and the hoist is started. Unless constant care is taken by the top filler to see that men are off the hoist after placing the barrows, an occasional error in premature starting of the hoist may result seriously, especially when the hoist is equipped at the bottom with safety gates which may drop and catch men stepping from the hoist as it unexpectedly starts upward.

The equipment of hoists with safety gates at the bottom was prompted by the occurrence of accidents to the bottom fillers. As they stood at the foot of the elevator to take the barrows off the cage
as it came to rest, their feet would often project over the sill and be caught by the descending elevator. These gates are now standard equipment. A gate still in use at the tops of some elevators is of the trap-door type, which is lifted bodily by the elevator as it nears the top. These are dangerous and should be replaced with side-lift gates.

No one should be allowed on the hoist after the cage has given the starting signal.

Accidents 5 and 6 illustrate the necessity of standing on a dry board or rubber mat, of wearing rubber or dry leather gloves, and of having tools thoroughly insulated with fresh tape, when working on mill circuits even of low voltage. These circuits are sometimes grounded, and especial precautions are called for.

Accidents like No. 7 demonstrate the need of safety hooks at the tops of portable ladders, as well as of spurs or nonslip pads at the bottom. If hooks are not provided, or can not be utilized, a helper should hold the ladder. If a man must use a pipe wrench while standing on a ladder, he should be especially careful to avoid positions that invite falls should the wrench slip.

Accidents like No. 10 are infrequent, as most plants have a wide pit so that men have opportunity to retreat from beneath the rubbish bucket as it is hoisted and dumped. No accidents are reported as the result of falls of men in getting into or out of pits, even though there are some pits where a considerable degree of agility is required. Neither were there any accidents reported to men while in the pit caused by being struck by skip cars, either by movement of the skip or the breakage of the cables. Safeguards are the provision of a wide and deep skip pit so that men can get out of range of the movements of the car, and the requirement that the skip cars shall be empty while the men are in the pit cleaning it. At a few plants the skip car is chained when men are in the pit.

Accidents similar to Nos. 3, 8, and 9 have suggested the following safeguards, which are widely employed: The use of a sheet-iron guard outside the skip-track rails; covering the bottom of skip hoists with sheet iron (see Pl. III, A and B), and the use either of a shield to stop flying rivets or the provision of a warning sign in the path of the flying material.

Accidents 12 and 13 happened to men with 5 and 10 years' experience, and illustrate the danger inherent in the loss of control of heavily loaded ore barrows. Several superintendents have stated that when a furnace is started with a comparatively new crew in the stock house, they always experience a series of accidents with hand barrows, the number decreasing as the men acquire deftness. In telling new men how to be cautious, accidents similar to these are of use as illustrations.
Accidents like No. 14 occur rarely but persistently and are usually serious. The only effective method of preventing burns from a steam exhaust or similar line is the provision of danger tags or locks to be placed at a steam valve when work is to be done on the line beyond the valve.

**FURNACE TOP.**

1. Laborer, with three other men under direction of foreman, was cleaning furnace top and was severely asphyxiated by gas escaping from about the try hole. D.

2. Larryman’s helper was helping to remove a piece of scrap that was stuck between the bell rod and the hopper throat. Was overcome with gas and fell from top of receiving hopper to top platform. C.

3. Stock-house foreman had opened manhole on gas seal over big bell and was looking in to observe distribution of ore on bell when gas ignited and exploded, burning face. D.

4. Larryman’s helper was cleaning top platform. Cleanings were shoveled in through gas-seal door and gas exploded inside and blew them out of the door over man’s face. D.

5. Three men were sent to top of furnace to remove scrap caught between little bell and its seat. Door on gas seal was opened to loosen scrap, and as the door was opened gas exploded. D.

6. Furnace was shut down for changing cooler. Water-seal valves were filled, isolating furnace, and stock-house men were sent on top to clean up about platform and explosion doors. An explosion occurred in the furnace above the stock line and blew one man from an explosion-door platform to the ground. A.

7. As rigging gang was placing new plate in receiving hopper, man fell from top of the hopper to the furnace-top platform. A.

8. Rigger was carrying chain up ladder to platform over hopper when he slipped and fell. D.

9. Man employed in repairing top rigging had scale blow in eye. Scale was removed by fellow workman and infection resulted. B.

10. Sweeper dumped barrow into hopper and, in pulling it back, barrow swung and scraped hand against side post. C.

The furnace top, in the past notoriously dangerous because of escape of gas, has become less dangerous on account of the tight construction now in vogue. To men working about the top platform, the only menace from escaping gas is usually from gas escaping from the try hole. It is the practice at a few plants to keep on the furnace top a quantity of asbestos rope with which to pack the try hole when men are cleaning or examining the top platform sheave wheels, rodding holes, or operating cylinders. This simple safeguard is efficient and is to be recommended.

When it becomes necessary to work about the receiving hopper or on the sheave-wheel platform on top of the receiving hoppers, men are not uncommonly exposed to gas. In 1914 three accidents from this cause occurred. In one, while a millwright was repairing the telltale on the sheave-wheel platform, he was overcome, and
A. SKIP INCLINE COVERED ON BOTTOM; PERMANENT PLATFORM FOR SPRAY IN SHELL.

B. SKIP INCLINE ADEQUATELY PROTECTED.

A, Steel-plate sheathing to prevent material from skip cars from falling on workmen passing below; B, stairway for workmen making repairs; C, handrail; D, chute for collecting falling material.
his helper started to assist him down the ladder to the top platform. Both fell about 18 feet. The helper lost 2 days and the millwright 240 days. Another man, while oiling the sheave wheels over the receiving hopper, was overcome and fell in attempting to descend, receiving a fractured skull and rib, necessitating a long layoff.

On account of the imperfectly tight seal of both big and little bells against their seats, work of the above description should not be undertaken until the stock-house foreman has been notified and until a round of ore has been charged onto the big bell, with the last skip load, preferably of fine ore, on the little bell, to seal them as much as possible. The bells should not be operated while the men are on top. Two men should be assigned to even the most trivial routine or occasional job on the furnace top, as it is impossible to foresee dangers from escaping gas. A millwright going alone to the top of a modern furnace, in direct contravention of a long-standing rule, was found fatally asphyxiated by his helper, who followed him a few minutes later. This accident occurred in 1915 in another State and indicates the imperative necessity for strict adherence to the practice of having two men on such work.

For the use of men on top, who are in danger from gas, there should be installed a signaling device, preferably an electric gong placed in the cast house and operated from the top only. One plant has a good practice of requiring a brief signal to be given every 10 minutes, the omission of the signal being notification to the stove tender to investigate. At a few plants, for work around tops where excessive quantities of gas escape, or for work for a few minutes in a locally gaseous atmosphere about or over the hopper, half-hour oxygen breathing apparatus are used with success.

When it is necessary to examine the big bell through a gas-seal door while the furnace is in operation, or if it is the practice to shovel top cleanings into the big-bell hopper through a gas-seal door, the gas should be lighted by throwing in a bunch of burning oily waste. This should be thrown from a distance of at least 6 feet or should be put in with a long rod. When the gas has ignited, a gas-seal door on the opposite side should be opened and the little bell lowered. The gas should be kept burning by keeping a bunch of oily waste continually burning inside the hopper. This practice prevents an accumulation of gas and air in explosive proportions. Such mixtures explode violently even in the absence of any flame and at temperatures usually considered below the ignition point. Speculation on the cause leads nowhere; the condition is well known, and accident is prevented by keeping the gas burning inside the gas seal.

Opening gas-seal doors, which must be done before the gas can be lighted, is not usually dangerous, provided it is done quickly and the men get away immediately. The little bell should be kept shut to
prevent an induced draft of air into the gas seal. When the little bell is wedged open by a piece of scrap, the work must be approached with caution, as the gas is apt to be unduly hot on account of enforced delay in charging, and on that account is more apt to explode when the gas-seal door is opened and air is drawn in by the open little bell. The most effective safeguard against an explosion under these conditions is a \( \frac{3}{8} \)-inch or \( \frac{1}{2} \)-inch steam connection to the gas seal. The seal can then be filled with steam before the doors are opened. However, when the little bell is blocked with scrap, it is safest to take the blast off from the furnace, draft the gas back through a stove, and turn steam into the dust catcher, the furnace being isolated by water-seal valves from others in operation; a single furnace should have all burners shut. The big bell is kept shut, the little bell being open. The gas-seal doors can be opened within a few minutes with no danger either of explosion or asphyxiation. The vital point is a steam connection of adequate size. Three inches may be fixed as standard; there are a few 4-inch connections. J. W. Dougherty is entitled to credit for the impetus and publicity given this practice.

The accident resulting fatally shows that gas explosions at the top may be of considerable violence. That they usually are not is beside the mark. Preparations are necessary always to prevent the explosion assuming serious proportions. Even with the furnace drafted back there is usually a somewhat vigorous generation of gas within the furnace, sometimes sufficient to give a strong flame at the bleeders or burner if one or two are left turned on. Consequently, there is likely to be an accumulation of gas above the stock line, or top of the burden, in the furnace. When the furnace top is opened, either at the gas seal and bells or at the bleeders and explosion doors, and air enters, there is every probability of a sharp explosion. Even when a door on the gas-main system remote from the furnace top is opened and air is drawn up to the top by draft through an open bleeder an explosion is probable.

When a furnace is shut down for changing a plate, cooler, or tuyère which have been leaking badly, work on top is extremely dangerous, unless the most stringent precautions are taken. While the furnace is thus shut down the hydrogen content of the furnace gas will be higher. Instead of being 2 to 6 per cent, it may be as high as 15 per cent, and has been found to be more than 30 per cent. The hydrogen makes the furnace gas unusually explosive, and the gas may be "wild"; that is, coming off in unduly large volume. As a general rule, work about hoppers, bleeders, and explosion doors should be left until later unless the work is imperative. Cleaning the top can not be said to be in this class and is better left for some other time. If the work must be done, the bells and the explosion doors
should be opened and the gas on top of the stock line should be lighted with burning waste, either dumped in by the skip or thrown in by hand; the gas should be kept burning, and some one should be stationed to see that it does burn, and to keep a fire of waste going, throwing in the waste through the bell. The alternative is the use of steam.

To provide security for men replacing wearing plates or removing obstructions in the hopper, a permanent platform should be provided. It is provided at some plants, but is far from being standard equipment.

WORK INSIDE FURNACE AND ON FURNACE SHELL.

The work inside the furnace stack is confined to construction and relining, and accidents for the most part occur in connection with work on scaffolding, handling brick, rigging, and salamander removal.

1. As laborer was loading brick from pile of brickbats pulled from inside furnace, large tile rolled onto foot. C.
2. Laborer was picking up brick from pile when one rolled down on hand. D.
3. Laborer was piling brick inside furnace and caught fingers between two heavy shapes. D.
4. Brick fell from tub while it was being hoisted and hit laborer on head. D.
5. As laborer was piling brick in bucket, brick fell off working platform above onto arm. C.
6. Laborer's hand caught between bails of tubs as he was guiding empty to one side. D.
7. As bricklayer was cutting brick, fellow workman bumped elbow, causing him to cut palm of hand. C.
8. Small spall of brick being cut by workman embedded itself in eyeball of fellow workman near by. D.
9. While laying brick, man reached for brick just as helper put down armful; hand bruised. D.
10. Laborer was tearing lining out of bleeder, standing on lining inside pipe as he dislodged the brickwork. He missed his footing and fell through the bleeder, bruising leg, body, and face. D.
11. Man on scaffold outside of furnace shell fell when scaffold broke, falling about 24 feet. B.
12. While riveting from scaffold, rigger walked to end of board which was not fastened down. Board tilted, causing man to fall. A.
13. Five men were working on stack scaffold when it collapsed, throwing two men to the ground. The others grasped the top of the plate work on which they were working when they felt the scaffold going. A severe storm had weakened the scaffold on which 14 men had previously worked, and its condition was not observed. One A and one B.
14. Two men lowering steel plate received injuries when the tackle broke. Both D.
15. Man was holding bar for another to strike and was hit in chest, on account of standing on the same side as the hammer man. D.
16. Helper was digging out rubbish and brick inside hearth and was overcome with heat. D.

17. Hand of man holding drill for drilling hole in salamander became infected from contusions and blisters. D.

18. Rigger was standing on plank drilling hole for dynamite in salamander, when plank turned, letting foot down into hot water. In getting out, put other foot in. C.

19. Man was struck by piece of iron flying from blast in a salamander. D.

For pulling brick from the furnace, men should be given long hoes to enable them to stand away from bricks tumbling and rolling down the face of the pile. When men are loading and wheeling brick away from a pile, the "straw" or "shift" boss in charge at the bottom should have the men keep the brick pulled down to prevent a steep slope on the face of the pile.

The falling of bricks from hoist tubs and down through shafts from the working platform can be prevented by care in loading, or by using a tub with a cover attached to the bail, the cover closing automatically when the hoist is made. The working platform should be provided with trapdoors over the bucket shaft, and also over the ladder shaft, to prevent the falling of brick. (See Pl. IV, A.)

Injuries occurring from handling material can be eliminated only by not rushing the work too fast, and by carefulness in taking brick from the chutes and in laying them on the pile or bucket. In laying brick, the usual hazard is injury to the eye from flying pieces caused by chipping or cutting the brick to shape. Many plants now furnish goggles to bricklayers if cutting is necessary. Other injuries are caused by accidental hitting of the hand with the mason's hammer or by having the hand caught between brick in handling them.

Scaffolds (Pl. IV, B) should be erected and inspected with great care. The injury from a fall is often out of all proportion to the height of the scaffold. Thus two men fell from a height of only 13 feet when a hemlock board broke inside a furnace. One man had both ankles broken, entailing a disability of 104 days; his companion lost 11 days from concussion and laceration of scalp.

The construction of temporary and emergency scaffolds is sometimes left to millwrights, riggers, or handymen, and any material available is hastily utilized. This practice leads to makeshift scaffolding, weak in uprights, and with knotty, cracked flooring. Only experienced and reliable men should be employed in the construction of scaffolds, and the master mechanic should delegate to some competent carpenter the duty of inspecting scaffolds before they are used. The most desirable lumber is long-leaf yellow pine. It should be free from cross-grain, knots in groups, or decay. When the span is 12 feet or less, planks should be not less than 12 inches wide by 1 5/8 inches thick. For a span that is between 12 and 20 feet, planks not less than 12 inches wide by 2 5/8 inches thick should be used. When
A. SAFETY ARRANGEMENT FOR ELEVATOR USED IN RELINING BLAST FURNACES. RISING ELEVATOR LIFTS TRAPDOOR COVERING SHAFT. PINS PUSHED THROUGH STRAPS IN ELEVATOR FLOOR PREVENT LOWERING OF ELEVATOR WHILE MEN ARE ON IT.

B. SAFEST WAY TO WORK ON SIDE OF BUILDING. ERECT A STANDARD SCAFFOLD, AND USE PROPER DANGER SIGN.
more than two men are to work on the scaffold, a center support should be provided every 8 feet. The planking should cover the entire span between supports, and should not project more than 12 inches at each end of the span. Preferably, planks should be nailed down; otherwise, to prevent the plank from slipping sideways, a hole should be bored at each end of the plank and into the support, and a bolt placed in each hole. Scaffolds more than 6 feet from the ground should have a railing, which should inclose the three sides, away from the working side, and be directly over the supports at the extreme ends so that men can not walk out too far and tilt the plank up. The uprights should be 2 by 4 inches for scaffolds less than 25 feet high, and 4 by 4 inches if 25 to 50 feet high, and if repairs or construction work is to be carried on from the scaffold and if brick or metal work is to be placed on it, a table of safe loads should be consulted and the scaffold made as much stronger as required.

Swing scaffolds are preferably suspended by wire rope, which should not be less than one-half inch in diameter. The eye of the cable should be passed about a thimble and be secured by not less than two rope clamps. Needle beams, if of wood, should be at least 4 by 6 inches, or, if of pipe, the pipe should be 4 inches in diameter. Eyebolts through wooden needle beams should have the nuts secured by a split pin, or provision should be made to prevent the ropes slipping off the ends of either wooden or pipe beams.

Before men go on the scaffold to work, it should be tested for strength at twice the load it is to carry, and a man should be appointed to inspect it at frequent intervals. The men working on the scaffold should also inspect it and satisfy themselves that it is safe. But as many workmen are incompetent to judge as to its safety, the primary responsibility should be with the master mechanic or man to whom the duty of supervision is delegated.

Work on scaffolds should be carried out deliberately enough so that false steps are avoided. Loads should be brought down gently, not suddenly or heavily, and no heavy castings should be leaned against the uprights.

In 1914 one man was killed and several others were injured while springing holes in a salamander. This work consists in enlarging the bottom of a row of 1-inch or 1½-inch holes, previously drilled in the metal, by setting off in them constantly increased charges of dynamite, starting with a half stick and working up slowly to two or three sticks per hole until a crack develops along the row of holes. Then a heavy charge is placed in the holes and fired, the object being to split the salamander along an axis. This work is dangerous if the holes are not thoroughly flushed with water between each charge in order to dissipate any heat imparted to the walls by the explosion of the preceding charge. It is also dangerous
if the salamander is not thoroughly cooled off before the dynamite is charged. At temperatures above 175° F., dynamite becomes acutely sensitive to shock or to spontaneous ignition, and a great risk is taken when dynamite is charged in a salamander above that temperature. Before the hole is charged, the temperature should be determined by lowering a metal-inclosed thermometer into it; if "springing" or "chambering" is practiced, the hole should be cooled with water and its temperature should be determined with a thermometer at frequent intervals. The temperature should not be determined by putting a wooden stick or pocket rule down into the hole to see whether it chars, because the temperature at which wood chars is too high for safety. When the holes become persistently hot, the only even moderately safe practice is to roll each cartridge in a sheet of thick asbestos paper, with a wad of loose asbestos at the bottom, and to lower it thus insulated.

If dynamite is charged loose and stemming is employed, it is absolutely essential to use a wooden tamping bar. Although metal bars are sometimes used in earth, they will inevitably set off charges if they are used in metal-inclosed holes.

Shot firing is almost universally done with a firing machine. Precaution should be taken not to use a greater number of detonators than the rated capacity of the machine. The detonators should be connected in series, and the ends of the lead wires should remain disconnected from the machine and in the hands of a responsible assistant until the foreman has made all connections to the charges in the salamander, has given warning, has stationed guards, and has reached the detonating machine. The lead wires should always be carefully examined each time. It is better to get new wires than to twist broken ends together or to patch defective insulation, for any unnecessary resistance or grounding in the wires makes the chance of misfire more probable. A misfired cartridge or charge in a salamander is probably one of the most dangerous misfires with which one can contend, because the heat in the salamander is apt to set it off after the danger is thought to be past, and while attempt is made to remove it or to set it off again by digging down to it through the stemming, or by drilling a new hole near it. Some plants use the electric-light circuit with success to set off charges.

Both on account of the danger to furnace columns, and to life and limb, the hearth should be inclosed (Pl. V, A). Men should be stationed at every approach to the cast house, but out of range of flying pieces, to prevent any unwary employees from approaching. A curious employee wandered into a central Pennsylvania cast house just as a blast was set off. A flying fragment of salamander took off the seat of his trousers, causing no injury except considerable shock.
A. HANGING BULKHEADS MADE OF RAILROAD TIES, COMPLETELY INCLOSING HEARTH JACKET DURING BLASTING OF SALAMANDER; WOODEN PROTECTION ON FURNACE COLUMNS.

B. CAST HOUSE AND FURNACE BOSH.

Note grates over casting holes, railed walk on bustle pipe, shield protecting snort-valve lever, furnace pressure gage, and engine-room signal-whistle switch. Telltale light can be seen just under the gage.
In the past several fatalities have occurred in blasting salamanders, and it has become the policy of several companies to employ contractors specializing in such blasting, who do the work more quickly and efficiently and also more safely than is possible by members of the furnace force who only infrequently encounter the job.

THE FURNACE FRONT.

BUSTLE PIPE AND TUYÈRES.

Eleven of the total of 30 accidents reported from about the base of the furnace resulted from hand labor or the use of hand tools. However, the work was peculiarly characteristic of furnace duties and the circumstances should be of interest.

1. Tuyère man was cleaning and testing bosh plate and let it fall on foot. D.
2. Boiler maker's helper was placing bosh plate in furnace with block and tackle when the hitch slipped, causing him to fall. D.
3. Laborer on scaffold pulling plate allowed plate to fall on foot. C.
4. Handy man sat down on bustle pipe to pull on wrench, which slipped, causing him to fall off bustle pipe. B.
5. Hot-blast man was tightening bridle spring when wrench slipped off nut. D.
6. Larry man was helping change blowpipe, and pipe fell on his foot. D.
7. Keeper was using bar to guide blowpipe into tuyère seat and bar slipped, spraining wrist. D.
8. Keeper was holding bar to cut iron from tuyère while helper sledged. Helper missed bar and sledge landed on great toe of keeper. C.
9. Bottom filler was prying cinder from inside cooler, when a heavy piece rolled out onto hands. D.

With the exception of the fall from the bustle pipe, which occurred when the pipe was equipped with only a single hand rail, without intermediate rail, toeboard, or platform, the accidents are typical of the hazard of the work in changing cooling equipment and cleaning up messes or plugged tuyères. Cooling equipment is heavy, varying from the 110-pound tuyère or the 165-pound cooling plate up to a 600-pound cooler, so that being caught beneath by the appliances is apt to cause serious injury. Sledging, bar work, and wrenches also contribute a share of injuries. There is a better opportunity for supervision of awkward or unskillful methods of work about the furnace front, where work is almost always done under the supervision of a blower foreman, than at the trestle or stock house, where men are scattered along the entire length doing routine or minor emergency jobs away from the eye of any foreman.

The remaining accidents are typical of furnace hazards.

10. Hot-blast man was blowing dirt from eyesight, and as he lifted the eyesight hot dust blew under goggle shield, burning eyelid. D.
11. As helper was picking out tuyère and blowpipe with long bar through eyesight hole, cinder blew out, burning neck, face, and hand. D.
12. Blower was looking in eyesight when the glass blew out, blowing dust and hot glass in eye. C.

13. Tuyère man was loosening nut on bridle rod before crew put bar in eyesight to hold the tuyère stock up against the pipe. Blowpipe fell and gas blew out, burning face and ear. D.

14. Helper had hold of crossbar to help take down blowpipe when tuyère man turned water in tuyère. Escaping steam and hot water from discharge scalded back. D.

15. Helper was in the act of removing a discharge pipe of cooler in which the water had been turned off when some one opened the feed and escaping steam scalded abdomen. B.

16. Blower was claying up tuyère and the gas pressure was so strong that it blew hot coke from the opening, a piece falling into top of man's shoe. D.

17. As stove tender was helping plug tuyère gas blew out, burning face and arm. D.

18. Keeper was cleaning out cooler seat before inserting tuyère when an explosion of gas at the top caused flame and hot coke to shoot out of the tuyère opening. C.

19. As blower was taking the blast from furnace, cinder came back and burned through blowpipe, and as he ran to lever to throw mud-gun clamp down, cinder ran near him and one of crew turned hose on it to chill it. Steam scalded ankle. D.

20. Second helper was lying on bench under blowpipe when cinder came back and burned through the pipe, burning neck. C.

21. Tuyère had been turned down on account of leak. First helper was getting mud gun ready for cast, standing near tuyère, when iron suddenly came back in pipe and burned it, and flame and molten iron blew over man. B.

22. Helper was playing water on blowpipe and tuyère in which the iron was coming back. Blowpipe and tuyère burned and the molten iron exploded in contact with the water, burning tuyère out and burning helper on shoulder, arm, and back. B.

23. Furnace millwright and hot-blast man were on scaffold at bosh arranging to change cooling plate. The blast was on and the plate blew out on account of loosening brace. Both men were thrown from scaffold, one fracturing collar bone and other receiving burns. Both B.

Accident 10 could have been prevented by providing the eye-sight cap with a cable and pulley, by which the eye-sight cap could have been lifted from a safe distance, or by the use of the stopcock type of eyesight with long levers.

Accident 11 would perhaps have been avoided if the picking bar for tuyères and blowpipes had had a 12-inch or 15-inch bar forged on the end at right angles, as is done at several works.

Accident 12 could have been prevented had the blower been wearing goggles or been using a hand glass between the eyesight and his eye.

In regard to accident 13, beyond giving the bridle nut not more than two turns to loosen it, the nut should not be turned back until at least two of the crew have put their weight on a bar inserted into the eyesight. The bridle nut should not be turned back at all until the blast is taken off the furnace and the gas drawn back or the
relief valve opened. In 1914 a blowpipe was dropped before the blast was off and the workman was severely burned by burning gas shooting out over him. He suffered a disability of 20 days.

Changing tuyères is a hurry-up job. Every three minutes the furnace is off means a loss of, say, a ton of pig iron. Crews are frequently in great rivalry, and the average time for this job is carefully kept, and not infrequently is posted. The danger of too much haste is self-evident.

Sometimes, when the nose of the tuyère is burned away and the tuyère is leaking badly, the water inlet is closed and water is played on the outside face of the tuyère to hold it until the furnace can be flushed and the blast taken off. Usually when the blowpipe is dropped the tuyère is red-hot and wedged tightly in the cooler by expansion, and it is usual to turn on the inlet momentarily to chill the copper seat. That it is essential to wait until everyone is away from the front of the tuyère is evident from accidents 14 and 15.

The use of leggings or simply tight-fitting shoes would have prevented the injury in connection with accident 16.

Occasionally the wildness of the gas, or the back pressure from other furnaces on the line, causes a long, intensely hot flame of gas to be ejected from the tuyère. At such times the work of claying back the tuyère is most difficult, as the flame may be longer than the stopping hook, and the force of the flame ejects balls of clay thrown into the tuyère. At such times the water seal at the dust catcher should be shut before the tuyère is clayed back. Many plants do this regularly on a tuyère change, whether trouble is anticipated or not. If the gas is still very wild at the tuyère and drafting back through two stoves does not relieve it, opening the top usually relieves the pressure. However, this expedient is not good practice, because it heats up the top rigging and sheave wheels and brasses, and may weaken the skip cables. Furthermore, if the furnace is isolated, it may cause a "top shot," or explosion of gas.

Accident 18 illustrates the danger of keeping the top open while changing tuyères. Such an accident could happen also with burners or dust-catcher bell open, drafting air up through the downcomer.

The safest practice in changing tuyères is to isolate the furnace with a water seal, draft back the gas, turn steam into the dust-catcher, and, if the gas is wild, open the bleeder. This procedure obviates to the greatest degree any chance of a top shot while working at the tuyère. Instructions must be given the bell operator not to lower the bells while work is being done, as the falling material from the bell may cause sufficient jar to eject gas or coke from the tuyère, or a top explosion may occur. Care must be taken to see that the furnace has settled, or slipped if it has been hanging, before the blow-
pipe is dropped. An accident in which several men were killed occurred many years ago when the furnace slipped while men were working about the opened tuyères. To facilitate knowledge of the condition of the furnace charge—whether "hanging," "slipped," or "down"—it is advisable to install in the cast house a signal light operated by the skip man. The simplest is a red light, signifying "hanging," and white light, signifying "down" or "slipped."

Another precaution against ejection of flame and red-hot coke from tuyère openings while men are working at them is to be sure that the crew have the tapping hole nearly stopped, if the tuyère is being changed after a cast. Especially hazardous is the use of water or sloppy clay for stopping the tapping hole while a tuyère is being changed. In 1914 a man was burned about the face while claying back a tuyère because wet clay was used in stopping the tapping hole. The wet clay caused an interior explosion of hot iron which threw a jet of flame from the tuyère. Some years previously a man was fatally burned in this manner in the Pittsburgh district. It is safest not to change tuyères until the tapping hole is stopped.

Before the tuyère is pulled, the blower or keeper should be as sure as he can be, judging from his experience, that the coke at the face of the tuyère has been tightly and heavily clayed back. It is especially necessary to make a good job when cinder is lying in the furnace. Cinder is sometimes present even when none appears at the monkey, and it runs out from the tuyère abundantly when the attempt is made to clay back.

It is safer for every one who does not have to get close to the work, to stay on one side while a tuyère is being changed. However, a good job of claying back is absolutely essential.

The danger from burning blowpipes and bursting tuyères is difficult to control. The only precaution is to stand to one side as much as possible when playing a hose on a tuyère or blowpipe that threatens to burn through, and never to stand in front of a tuyère unless it is necessary. Signals to the stock house and the blowing room, as well as snort-valve levers and electric-burner connections should always be placed out of range if possible and should be protected by a shield (Pl. V, B) if they can not be put in a safe place. Emergency signals should be placed outside of or on opposite sides of the cast house for use when the signal regularly used in unapproachable on account of flying coke and flame from a burned blowpipe or bursting tuyère.

Analogous to the bad practice of loosening bridie rods before the blast is off is the practice of removing braces or loosening bosh plates, preparatory to changing them, before the blast is off, illustrated in accident 23.
Bosh plates should be secured in place by braces, when they are set in plate boxes, to prevent their ejection. The braces should not be removed until the blast is off the furnace. Plates set in brick arches are not usually braced or otherwise tied in, the pinching and cementing effect of the surrounding brickwork and clay packing being sufficient to hold them in place. Such plates should not be started with jackscrews or other pullers until the blast is off. Blowers should see that such expedients are not used on any pretext of hurrying the work.

CINDER NOTCH.

1. Keeper was using tapping bar to open monkey when cinder flew and burned foot. Was wearing laced shoes. D.
2. As keeper was opening monkey, iron came over with the cinder, burning monkey and exploding in contact with water. Hot metal flew over keeper's neck and body. D.
3. Helper was using picking rod to remove obstruction from monkey while flushing cinder. In removing rod, cinder flew into shoe. D.
4. As monkey boss was botting up, cinder splashed onto hand. C.
5. Keeper was botting monkey and at bot entered monkey explosion occurred, throwing slag over keeper's face. D.
6. As cinder snapper was botting monkey, helper held shield too far toward front of notch; cinder splashed onto cinder snapper's shirt, setting it on fire. D.
7. As monkey boss was botting up he fell and fractured his leg. B.
8. Pipe fitter was cleaning seat of monkey cooler when gas and coke blew out, burning his face and hand. D.
9. Man was passing wood through cinder notch to fill furnace before blowing in when piece jammed and struck eye. D.
10. Monkey boss allowed bot to fall on foot. C.
11. Cinder snapper received fracture of instep by "welshman" falling off tapping bar. B.

Opening the cinder notch is perhaps the least hazardous of work about the front. Small splashes of slag are frequently thrown out but rarely come in contact with the person. At one plant a large shield is employed. It is carried by two arms pivoted on an adjacent furnace column. The shield is used when the notch is opened or closed, the tapping bar or picking rod being placed in the cinder notch through a hole in the shield. Small shields, from 15 inches square up, are also used when the cinder notch is opened to prevent small splashes of cinder reaching the man working alongside the fall or runner. (See Pl. VI, A.)

The same type of accident as Nos. 4, 5, and 6, with little variation, occurred at other plants, involving a cinder snapper, a monkey boss, and a keeper, with experience of 2 to 14 years. The injuries caused loss of time of 8 to 16 days, being burns of wrist, forearm, face, and feet. Such injuries are most effectively prevented by having men wear welder's masks—a shield of fine, strong wire gauze tied about
HAZARDS AT BLAST FURNACES AND ACCIDENT PREVENTION.

the hat, and extending down to the chest or lower neck and back to the ears—gauntlet gloves, woolen or hard jean cloth clothing, and tight shoes. The arms should not be exposed. It is helpful to have a plate shield alongside of the cinder fall, the end next the notch being far enough away so that a picking rod or bot can be manipulated.

Most of the 11 accidents outlined could probably have been prevented had the men been wearing proper clothing and been provided with welder's masks. Similar accidents can be avoided by the use of an automatic bot of the type shown in Plate VI, B. Such a bot has been tried for two years at an increasingly large number of plants and has proved satisfactory even with excessively heavy limy slags, and with no danger of explosions when it strikes molten iron coming over the monkey.

At various plants cleats or ribbed plates alongside the cinder fall are provided to insure a firm footing. An accident several years ago shows the desirability of such cleats. A monkey boss slipped while botting the monkey and fell into the cinder fall or runner, which was full of cinder. He received severe burns.

Regarding accident 8, it is probable that an attempt was being made to change the monkey before the blast was off the furnace, in order to avoid delay. Many accidents have occurred in this way. It goes without saying that such a practice is to be discouraged, for although the change can be accomplished repeatedly with impunity, sooner or later the skull of chilled cinder, set up about the monkey, is sure to collapse and cause severe injury.

Probably no amount of foresight on the part of others than the injured men would prevent accidents like the last three mentioned. Injuries received in the course of handling tools and material are essentially due to some careless movement or method of work. Continual insistence on the need of personal skill and caution throughout the plant is practically the only method of preventing such accidents.

TAPPING HOLE.

1. Keeper was loading mud gun before cast, shoveling in clay while the helper operated valve. Clay plugged in the bottom of funnel and keeper put hand in to push clay down; plunger came back and cut off end of middle finger. C.

2. Helper filled clay cylinder of gun with water to clean the cylinder; turned on steam to push out the mud and clay; stepped to front and loosened stiff clay in nose with bar. Plug gave way, hot water scalding hand. D.

3. Helper turned steam into cylinder to clean it. The cylinder had been filled with water, and the hot mud shot out suddenly over a cinder snapper passing in front of gun. C.

4. Cinder snapper was in trough, ridding up after cast. Helper was taking gun from hole and turned on steam to help swing gun. Steam from exhaust burned cinder snapper's leg. C.
A. CINDER SHIELD IN ELEVATED POSITION. SHIELD IS KEPT UP WHEN CINDER IS RUNNING TO PREVENT ITS DESTRUCTION.

B. AUTOMATIC WATER-COOLED BOTTING MACHINE IN POSITION. OPERATOR NOT IN DANGER ZONE.
5. Helper was throwing clay into gun when steam hose extending from jet of gun crane to valve burst, scalding chest and arm. D.

6. First helper was swinging gun into hole. Nose of gun struck molten iron in hole and caused iron to explode. B.

7. First helper was swinging gun into hole. Nose of gun hit slag and iron lying about hole and caused slag to fly up, burning helper's neck and shoulder. D.

8. A cinder snapper stepped up to gun to turn on steam after gun had been clamped in hole, splash of cinder blew from hole and burned face and neck. D.

9. As keeper was operating valve on gun, cinder came back, flew, and burned wrist and hand. C.

10. Third helper standing between furnace column and clay gun was throwing clay into cylinder funnel of mud gun. As the load in the clay cylinder was discharged into the hole and the plunger was drawn back, cinder and gas came back and burned helper. B.

Other accidents occurring in connection with closing the tapping hole are discussed in another section.

Accidents to the feet or hands, like accident 1, occur both when funnels are used on the clay hole and when they are not. The only safe way of loading the gun appears to be to have only one man do the work. This rule is in effect at several plants, and has not proved impracticable, as the keeper, or other cast-house man assigned to the work, soon becomes adept at throwing and pulling the valve lever with his shovel. Although it would be possible for him to put his foot into the hole as he throws the lever, he is not likely to do so, and the method offers less chance of accident than any other except loading the gun from the nose, with a wooden plunger, which is more laborious, slower, and perhaps not as satisfactory.

As regards accident 2, the use of water to loosen and clean out stiff clay in the clay cylinder is common practice. Only the most careless foremen would permit a man to stand in front while the cylinder is being cleaned. The clay in the nose of the gun is always very hot and is usually stiff from being left in the tapping hole, with the lower part down inside the hot trough. It is better practice to pick out the hard clay in the nose with a bar before cleaning the clay cylinder.

As regards accident 3, aside from the carelessness of the helper, the management was deficient in not having the exhaust from the gun turned up and to one side, so that steam would exhaust away from men working in the rear of the gun, either during the cast when the steam cylinder was being warmed, at the end of the cast when the gun was swung to the hole by hand, or after the cast, when men were ridding up the trough before the clay in the hole had set and the gun was removed.

The fitting of the gun with pipe and swivel unions would minimize the probability of an accident like accident 5. The use of even wire-wound steam hose is not regarded with favor.
Since the introductory use of the Berg gun, in 1913, it has been adopted in many plants because of its efficiency and safety. The following extract, describing it, is taken from an article by Berg:

The general method of plugging a blast-furnace tapping hole is to take the blast off the furnace, and stop the hole with a clay gun. The clay barrel of this gun is filled with clay before the furnace is tapped, and when all the iron and cinder has been tapped and the tapping hole begins to "blow," the blast is reduced to about 5 pounds pressure by slowing down the blowing engines; then the snort valve is opened, and sometimes the cold-blast valve on the stoves closed to take off all blast pressure in order to prevent gas from blowing out at the tapping hole, so as to allow workmen to insert the gun by hand and force clay from the gun into the hole by operating the three-way steam valve attached thereto, and by throwing small balls of clay into the gun until the hole is plugged, when the snort valve is closed and blowing engines are again signalled to go ahead at operating speed. This performance is not consistent with perfect safety of the workmen. * * *

The Berg gun is supported by a boom attached to a revolving sleeve on the furnace column and swings in and out of the hole by steam cylinders through cables. It swings horizontally by the first part of its travel, and then a chain attached to the rear of the gun tilts it during the latter part of the travel until the nose is on the same elevation as the iron notch; then the dogs on a shaft, turned by a steam cylinder, grab the gun and move it over the suspending trolley wheel into the iron notch and hold it there while the clay is inserted into the hole; the entire operation taking only one man, at a safe distance, to handle the different valves. * * *

The great advantage of this gun over the old method is, mainly:

1. The absolute safety of the workmen, as no men are exposed to flying sparks of iron or cinder, or the flames of burning gas as in the method generally used, or exposed to extreme heat while stopping the hole. * * *

2. Ability to stop the hole with full blast on whenever the furnace is working badly, with cinder or iron running back in the blowpipe. This is sometimes nearly impossible with the old method without exposing men to the danger of getting burned.

Mention should be made of the Gerwig automatic clay gun. This operates slightly differently, but is a prior invention.

The use of automatic clay guns is advantageous beyond question. There is, however, little occasion for injuries of the character noted in connection with stopping the hole, as methods in use at different plants can be combined to give safe practice.

Before a nonautomatic gun is swung into the tapping hole for stopping it after a cast, the nose of the gun should be warmed or coated with oil to prevent explosions when the nose of the gun comes in contact with any iron that may be in the tapping hole. Warming is usually done by pouring a little hot slag over the nose of the gun. The practice is sometimes criticised because if too much heat is applied, the heat is apt to stiffen the clay in the nose of the gun.

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The danger from a plug of stiff clay is that the stiff clay may cause a "short" or "hard" hole, or if iron is laying in the hole, the iron may "come back" or run into the clay cylinder of the gun, and an "ironed hole" may be caused. Aside from the splash or spitting back of iron upon the men, there is a possibility of breakout at the tapping hole at the next cast when the hole is being opened, also the possibility that the hole will be so obstructed that the cast will be delayed far beyond the usual time for casting. The level of iron within the hearth will then become higher and higher, and unless the blast is taken off before the iron gets up to the level of the cinder notch, there is the probability that the monkey will be cut by the molten iron and will explode. Also, a hard or ironed-up hole during a cast causes increased danger of a hearth breakout as the iron gets higher. The downward and lateral pressure of the iron becomes much greater, and consequently the iron tends to penetrate the joints, interstices, and cleavage cracks of the brickwork.

When the end of the gun is covered with oil as a protective measure, any heavy oil is used and the nose is liberally daubed before the gun is placed in the hole. For some reason, even ice-cold iron covered with oil will not cause an explosion when it is plunged into molten iron.

Another excellent practice used at a few plants is to remove 1 to 3 inches of the clay at the front of the nose of the gun, and refill the cavity with sand or ground ganister in fairly stiff mixture with heavy oil or hot tar. The mixture eliminates still further the possibility of explosions of molten iron in the hole from wet or sloppy clay at the nose of the gun coming in contact with the hot iron, which may blow slag and gas back on the crew. The oiled or tarred sand acts as an inert barrier between any poorly mixed wet clay and iron with which it may come in contact.

InFrequent Tapping-Hole Accidents.

Other characteristic accidents, not of frequent occurrence, but of sufficient possibility to deserve mention, are as follows:

1. Splashes of cinder or iron caused by pushing the gun into the hole before the trough is drained.

When the cold or wet nose hits the molten material, an explosion or splash may occur. This may be avoided by giving the iron trough sufficient slope so that the slag and iron lay away from the hole when the iron and slag has been tapped and the blast taken off the furnace. It is usual to drain the trough before stopping the hole, but some few plants, to save time in stopping the hole or to get a better skim on the slag and iron remaining in the trough, postpone
draining until after the hole has been stopped. An adequate slope of the trough is then essential.

2. Explosions or splashes of iron when the nose of the gun is placed in the hole against a stream of iron.

Occasionally it is necessary to use the gun to help stop an unexpectedly large cast of iron. Explosion may be avoided by having the nose of the gun oiled, or warm and dry. To prevent splashes, a shield may be placed over the nose of the gun, ahead of the clamp bar (Pl. VII, A). The shield should be shaped to fit in the trough, being widened above the trough.

3. Flashes of gas and splashes of cinder when stopping clay does not fill tapping hole.

The shield mentioned above is an aid in preventing injuries from this cause. If shields are not used, a practice that should be followed is to form a fairly large lump of clay over the top and side of the gun nose. A simple method of avoiding “throw-backs” of slag, iron, and gas when the first load of the clay cylinder is discharged is to turn the steam on by a valve placed behind the column next to the tapping hole. A few plants use a long hook, thus enabling the keeper to stand off a considerable distance in shooting in the first load of clay. One superintendent insists that the keeper use this rod, not only for the first cylinder load of clay, but for the second reloading and discharging. The second helper, who has the duty of supplying the clay as the keeper works the plunger, should use a long-handled shovel to throw the clay in the funnel, instead of standing up under the blowpipe between the gun and furnace column.

4. Injuries received on account of the hole blowing hard when the gun is put in.

Such injuries are extremely rare. With few exceptions, the opening of the snort valve, at the end of the cast, closes simultaneously a butterfly valve in the cold-blast main, just beyond the snort valve on the hot-blast stove side. Although the butterfly valve is not usually set to close tightly, on account of the apprehension that gas will come back in the hot-blast main from the furnace, the amount of air blown into the furnace is slight, being sufficient to keep up only an inconsiderable current in the stove and blast line.

Less in favor is a relief valve on the hot-blast line. This valve, when installed, is often clamped shut and never used. At a few plants, it is opened immediately after the snort valve is opened in order to stop instantly any blowing on the hole, thus obviating the need of putting the gun into the hole while the pressure is reducing through the tapping hole, or the need of delay until the flame dies down. If relief valves are used care is necessary in repairing them, as in one instance an explosion at the valve, with the gas drafted back
A. MUD GUN EQUIPPED WITH BELL-SHAPED NOZZLE AND STEEL SPLASH GUARD.

B. SHIELD FOR PROTECTION IN DRILLING TAPPING HOLE.
past it to a stove, knocked a millwright about 16 or 18 feet to the pavement. If the relief valve exhausts in the cast house, a ventilator with hood immediately over the valve should be provided to prevent the fumes from rising about the stack, where work may infrequently be necessary.

Whenever the flame at the tapping hole is strong and hot, it can usually be stopped by shutting the cold-blast valve of the stove on blast. The safest practice is to shut it to the position for filling the stove with wind, thus keeping some circulation of air in the blast-main system. It is never safe to shut down the engines entirely. Some costly explosions, both to life and property, have been caused by shutting engines down at cast time and leaving the blowpipes up and the tuyères open. A small quantity of wind is imperative, unless automatic check valves are used, or the stove is taken off the blast-main system. Even then valves may fail to work or some one may be negligent in his duties, when there is every chance for a blast-main explosion. Well-designed snort valves and cold-blast main butterfly valves do away with causes for injury at the tapping hole and prevent blast-main explosions.

ACCIDENTS CONNECTED WITH OPENING OF TAPPING HOLE.

Nine of the reported accidents involved in opening tapping holes were caused by the use of bars and sledge. A helper ran a sliver of steel into his hand while using a tapping bar; another’s hand was hurt by splinters from a sledge; a keeper was struck in the ear by a sliver from a mushroomed bar. While holding a tapping bar one man was hit on the hand, two on the side, one on the forehead, and one on the temple. One keeper was hit on the wrist by a sledge flying off the handle. The disability ranged from 3 to 14 days, averaging 6 days.

Two men are usually employed to hold a tapping bar in order to keep the bar jumping and to prevent it from freezing in the skull, so that one man has to be on the same side as the man with the sledge. Broad-face sledge of the “Oregon” type are to be preferred for this work. Experience in sledging does not mean immunity from accident, for fatigue depletes the skill.

One plant employs tongs, the bar being placed in the hole and in the depression of a V bar, and held by men who, on opposite sides, grasp the bar with a long pair of tongs and who are enabled, with a little experience, to hold the end steady. In another plant the bar is placed on a crossbar over the trough, and is clamped down by bars held from opposite sides. The men, in addition to immunity from blows of misdirected sledge, are out of the way of any sudden outbreak of iron from the tapping hole.
Defective tools, such as mushroomed heads of bars and hammers, split sledge handles, loose sledge heads, and splinters of steel or wood, should be looked out for by the blower.

Twenty injuries were due to burns, received while men were opening the tapping hole. Six of the injured men were experienced in opening the tapping hole with a hand or churn drill. From four to as many men as can get hold of the drill, which may be 24 feet long, are employed in opening tapping holes; usually six are employed. Three "spells" or turns at "drilling up" are commonly taken. The men next the tapping hole are bent over, and both their hands and their feet are exposed if the hole breaks through.

Two injuries, burns of wrist from hot clay blowing out and burns of ankles and feet from hot metal, were due to the iron coming out unexpectedly on the second "spell." The disability was 15 and 60 days.

Four injuries were caused by iron breaking or blowing out, unexpectedly or with unusual violence, in the third or last spell. The injuries resulted in disability of 6, 14, 30, and 30 days, caused by burns of fingers and wrist, arm and side, and left and right lower limbs. The experience of the men injured ranged from 3 months to 10 years.

Experience is of little avail to a man who takes a chance in opening the tapping hole, though it does contribute a certain intuition which guides experienced men in the handling of the drill as it approaches the skull of iron. Some oldtimers, however, will take chances, not only at the tapping hole, but everywhere about the furnace—chances that younger foremen will not assume themselves or permit others to assume except in most extreme necessity. However, the use of a hand drill up to the time the iron comes through is not very good practice. Not only are more men exposed to the possibility of burns, but a hand drill makes a bigger hole, which introduces a danger later on in the cast. It is much preferable to use a tapping bar to drive through the skull, after the crew have drilled out the clay in front of it. If a hand drill is used to get the iron out, the splasher should be placed, and a shield should be hung in the trough in front of the splasher. The shield can be slotted to admit the bar. A good practice is to lay a couple of sheets of corrugated iron over the trough up to the hearth jacket, with a hole punched in the sheet next the hole for the drill. The sheets should be laid over boards placed across the trough.

Four injuries were due to the use of air or electric drills. In one case an electric cable leading to a drill burned off as the result of a short circuit and the flash burned the keeper's hand, causing 18 days' lost time. Another keeper was burned by an outbreak in the tapping hole just as he was taking the drill from the hole. He lost 7 days
from burns of arm and wrist. The other two injuries were received while the men were still operating the drill motor, the drill biting through the skull and letting the iron out unexpectedly. The time lost was 10 and 11 days, caused by burns of chest and arms and of hand.

Some little experience is needed before an electric or air drill can be used with assurance of safety. Sometimes the drill will plug itself when it hits the skull. At other times it will bite through with no indication of approaching the molten interior. The safest practice is to use a shield in front of the tapping hole during the latter part of the drilling. The drill is withdrawn from time to time to remove the drilled clay from the hole. The use of compressed air to blow the dust out enables the use of a plate shield completely covering the trough and with a Z bar or angle riveted on at one end to be placed against the splasher. This device affords complete security. The front section with its angle may be made removable to afford a view of the tapping hole.

With a machine drill it is possible to make a much smaller and neater hole than is usually made with a hand drill. A 2-inch drill is standard for this work, although smaller ones are in use. By the use of a small hole the clay stopping in the iron notch is preserved against the attack of hot limy slag much better than when a large hole is driven down to the skull; the hole can be kept shorter, the use of an excessive amount of clay— with attendant uncertainty as to the length of the hole— can be avoided, and coke messes, flying coke and slag, and blowing out of the stopping during or after cast can be minimized.

Four injuries, causing loss of time of 6 to 10 days, were caused by the driving of tapping bars. No shields were used. In one instance a man was standing with one foot in the trough while he held the bar on which men were sledging. The skull broke in suddenly and iron blew out over his right foot and leg and also burned his hand. Lost time, 12 days.

In another instance the men had the tapping bar over a crossbar and were driving it in when the iron came out suddenly, hit on the crossbar, and splashed up on first helper's face and eyelids. Lost time, 7 days.

The third accident happened when a second helper was driving a tapping bar with a sledge. Flames shot from the tapping hole, burning his face and hands. Lost time, 10 days.

In the fourth accident the iron broke through quickly, throwing flame and hot clay over second helper's face, arm, and hand. Disability. 28 days.
The use of an adequate shield (Pl. VII, B) in front of the tapping hole should prevent such injuries in any plant where the bar is driven by hand.

Six injuries resulted from pulling bars from the tapping hole. As is evident from the review of accidents incurred while men were driving bars the iron at times comes out when the bar is driven. When the skull is heavy and thick and mainly composed of iron a “welshman” must generally be put on the bar, and it must be driven back by sledgering on the wedge. Two of the injuries were to men having hold of the handle of the “welshman.” In one case the hole was a little “green” or wet, and when the bar was pulled an explosion threw particles of hot iron over the man’s face and neck. Lost time, 6 days. A similar accident in 1914 caused erysipelas, pneumonia, and death.

Two men suffered burns of shoulder, back, and arms from flames and iron from the tapping hole when the tapping bar was pulled. Disability, 3 and 24 days.

One man received slight burns of face and ear when the iron burst out while he was using oxygen to burn out a tapping hole in which a tapping bar was stuck.

The sixth accident occurred to a keeper pulling a tapping far from the hole after the iron had come. The iron splashed up over his foot. Lost time, 16 days.

In pulling tapping bars the shield should be left in front of the hole until the bar is out; there is no necessity for removing the shield. In one plant, to enable the men backing the bar out to keep away from the trough, a sliding weight is placed on the bar and the men jar this against the “welshman” by yanking it up against the wedge with ropes attached to each side. In another plant, to enable men to keep away from the “welshman,” a cable hooked into a clevis attached to the “welshman” by means of an eyebolt passes over a sheave to near the cast-house wall, where the “welshman” can be held at the desired height and pulled out of the trough when the iron comes and the tapping bar is free.

Men working about the tapping hole should always wear goggles and good shoes, tightly laced and not gaping away from the ankle or with cracks in uppers or soles. Leggings are used at few plants. They have, however, been found practicable in certain plants outside the State.

Men not actually employed in opening the hole should keep away, and if it is necessary to walk in front should get across the runner quickly. Some years ago a foreman was superintending work on a hard hole, and was standing directly over the dam in the trough. He was caught by a sudden outbreak in the hole, receiving burns.
of abdomen and legs which caused several months' lay off. Care should be taken to keep the legs and feet out of the trough, even on the first spell, and while working to stand as much to one side as possible. It is safest to place a shield and splasher, or cover plate, in front of or above the tapping hole after the first spell, as it occasionally happens that the hole is weak, "short," or "green," and unexpected outbreaks of iron are almost inevitable from time to time.

TROUGH AND CINDER FALL.

1. Cast-house laborer was breaking a heavy skull of cinder in the runner when a piece of hot cinder flew, burning elbow. D.

2. Helper was crossing walk over cinder runner when an explosion of cinder in runner threw molten slag over back. C.

3. Cinder snapper stepped into cinder in runner while jumping across. C.

4. Water was dropping from bustle pipe onto cinder full and when cinder was flushed it boiled, throwing material into keeper's face. D.

5. While man was tapping cinder, it splashed over runner into man's shoe. D.

6. Cinder snapper was throwing wet skulls of cinder into slag ladle when there was an explosion which threw slag into man's face. D.

7. Cinder snapper was attempting to turn on granulating-pit water-spray valve while hot cinder was running down trough. Heat from cinder set man's clothes on fire. B.

8. Monkey boss was cutting off cinder in runner from one ladle to another, and before he could get gate down tight his trousers caught fire. C.

9. Cinder snapper threw ball of clay into runner to plug leaky shutter. Cinder splashed, burning wrist. D.

10. Cinder snapper received burns of foot by explosion of cinder as he was throwing wet coal in runner to aid in running a stiff slag. B.

11. Second helper, in removing splasher, was pulling on hook to swing splasher around while others were on the lever. Splasher suddenly loosened and helper lost balance, falling into trough and burning body and legs. B.

12. First helper was placing splasher lever on splasher when hot metal was blown on him from tapping hole. C.

13. Helper was pricking tapping hole with bar when hot coke blew out suddenly, burning arm and body. C.

14. Helper was running pricking rod in tapping hole when obstruction in the hole suddenly gave way and he stepped into the trough which was full of iron. C.

15. Keeper was using rod on "mucky" hole when metal suddenly blew out, burning him. D.

16. Second helper was putting rod in tapping hole. When the cold or wet end of rod entered hole, explosion of hot metal occurred. C.

17. Keeper was cooling iron trough with hose so that he could rid up trough. Water hit pool of molten iron lying in trough, causing explosion. Eyes and face cut and burned. B.

18. First helper slipped into trough in which loam was boiling. D.

19. Keeper was loading clay gun. Plunger stuck, then flew back suddenly, causing steam cylinder head to fly off gun. B.

20. Cinder snapper pulled out lump of unchilled scrap from trough. Hot iron ran out on wet pavement and exploded. D.
21. Helper, in breaking crust on trough, let cold end of bar go through crust. It came in contact with hot metal in trough and explosion occurred. D.

22. Laborer, using bar to loosen scrap in trough, had torch hanging above him. Struck bar against torch, upset it, and spilled oil over clothing, which ignited. B.

23. Cinder snapper, in breaking cinder, slipped on rubbish and wrenched back. D.

24. Cinder snapper, while cleaning up about fall, fell and broke rib. B.

25. Helper let splash lever slip out of hand onto foot. D.

26. Lever hanger broke and lever fell onto foot. C.

27. Cinder snapper let lump of cinder fall on toes. C.

28. Laborer, while shoveling cinder and coke from "mess," burned leg. B.

29. Helper, in sledging bar, hit keeper on knee. C.

30. Helper let bar fall on foot. D.

Accident 30 is a form repeatedly encountered all about the furnace front and runners. The use of broad-faced sledges for this work and standing on the opposite side of the bar from the man sledging it are about the only precautions to be taken in this work, but they will greatly help to eliminate this type of accident.

Keeping pavements cleaned up after each flush, cast, or mess is usual practice. Sometimes, however, accumulations of broken small cinder are allowed to collect. Keepers should keep floors and pavements clean.

The accidents in which men were injured while turning on water or operating shutters illustrate the type of accident in which men knowingly take a chance that involves their own safety when there is at stake the necessary performance of a task which, left undone, would probably result in expense to the employers for cleaning up the resulting mess or for repairing or replacing cinder-ladle equipment. Men are rarely asked or ordered to take these risks by their foremen; they take them voluntarily. Whenever safeguards can be installed to take care of contingencies that are fairly sure to happen, they should be installed. Spray valves for cinder pits should be placed at least 10 feet from a cinder runner and at least 20 feet from the pit itself. It is often possible for shutters to be so arranged that the cinder can be diverted by lifting the gate, not by having to jam it down, which requires a longer time. Better than hand-operated shutters are shutters that can be pulled or dropped by means of cables and sheaves at some spot away from excessive heat and out of the range of splashes or flying slag. When the shutter is dropped a guide is necessary. A steam-operated cylinder for cinder-runner shutters has for years been used at one furnace plant.

Boils in cinder runners are, fortunately, rare. When iron is coming over with the cinder, however, a damp spot in a runner will start a boil or explosion. To keep water from falling onto the cinder runner a shield, half circular, should be hung beneath the bustle pipe, di-
rectly over the cinder notch and extending out at least a foot on each side above the sides of the runner. This also prevents leaking or spattering discharges or feeds from running down over the bustle pipe.

The throwing of skulls of wet cinder into ladles of slag should be prohibited. It is just as dangerous to put them in empty ladles before running cinder, probably much more so, as they may cause an entire ladle of cinder to boil over or explode. Flipping or throwing coal or wet clay into cinder runners when the top is crusted is a frequent practice, though of doubtful advantage. The appearance of flame and occasional cracking and lifting of the crust as the steam or gas from the clay or coal is forced out is deceptive in that it seems to indicate a lively slag. Although the hazard of the practice is only trifling an occasional severe injury may be anticipated.

A steel-plate walk across a cinder runner at some place between the cinder notch and the ladle or pit is desirable. Men step across these places, and as the radiation and glare are frequently too intense to allow them to see and judge accurately their footing before they step, a misstep is occasionally made. The injury to the man crossing a footwalk just as an explosion occurred serves as a reminder that unnecessary approach to runners full of molten metal or slag is to be strictly avoided. Too much stress can not be laid on the requirement that blowers and crew acquaint themselves with the work so that there is a minimum of crossing and recrossing runners to get tools or to perform some forgotten job.

The best precaution against accident in removing the splasher is to pull it up and swing it away with a chain attached to a cable that passes over a sheave to a lever or steam cylinder at the cast-house wall. With this arrangement no one need be in a position to get burned or injured by a misstep or by the dropping of the lever. Another method is to suspend the splasher on a small trolley running up a monorail over the trough at an angle of about 60°. This device is, however, more expensive and offers the objection of suspending a heavy weight over men working about the trough between casts.

The relatively few accidents occurring from the use of the picking rod, which must be used at almost every cast, show that the hazard is not great. When a deep splasher is used and men are careful not to put their entire weight on the rod when it meets an obstruction, there should be little danger. Many blowers check the furnace when it is necessary to use the picking rod, and when there is, in their judgment, a chance of a burst of flame or hot slag, metal, or coke. The usual protection is a corrugated sheet placed upright alongside the trough, behind which the men crouch.
The closer this is to the splasher, and yet leave room in which to work the picking rod, the better the protection afforded. The picking-rod end should always be held over the slag or iron in the trough a moment to warm it before the rod is put into the hole. The safest way to bend the rod before use is to bend it about a column or between the gun crane and a column. A serious injury may be caused by one man standing on the rod while another lifts up on the end to put an angle on it.

Every year there are a number of similar accidents caused by putting water on the trough during ridding up. As the result of one on record a man lost the sight of both eyes. A man should wear goggles when turning water into the trough preparatory to cleaning it after a cast. The use of a special device on the hose adds to the safety. A 16 to 20 foot pipe is connected to the hose and on the end an elbow with a hose nipple or sprayer is placed. Every one should keep away while the water is turned into the trough. By moving the pipe, every part of the trough can be reached and thoroughly chilled. The work can then be finished up with an ordinary hose nozzle if desired. Another method is to place a holder on the end of the mud gun and to put the hose nozzle in it, turning on the water from the wall. However, this arrangement permits no flexibility.

RUNNERS.

1. Sampler put cold ladle into hot metal, causing explosion. Metal flew over keeper’s leg. D.
2. Helper poured dipper of metal into sample box, causing explosion of hot metal which burned his abdomen. D.
3. As man was carrying cinder in ladle to dry runners, cinder slipped onto foot. B.
4. Keeper was running iron and when he lifted shutter an explosion or shot occurred, because the iron struck damp sand. Face burned. C.
5. Man was throwing shutter to divert iron into nest chill when iron splashed over face, neck, and arm. C.
6. Keeper had placed scrap in runner to melt it, and when metal struck scrap, explosion occurred, burning him. C.
7. Helper threw skull of cold scrap into runner of hot metal, causing explosion. C.
8. Helper threw runner scrap into hot-metal ladle about half full, causing explosion. D.
9. Helper was raising “punch-out” gate when iron exploded or shot, burning arms and shoulder. D.
10. Second helper was in line with tapping hole when a shower of red-hot coke blew from the tapping hole, setting man’s clothing on fire. C.
11. Bricklayer accidentally stepped into runner full of hot metal. C.
12. Cinder snapper stepped on crusted slag and broke through, burning foot and ankle. D.
13. As keeper was watching iron run in ladle, spark flew into his eye. D.
14. Helper was struck in eye by spark from metal in runner. D.
15. Cinder snapper cut hand on scrap in lifting it into barrow. C.
16. Helper was loading scrap from runner into barrow and burned hand. D.
17. Cinder snapper picked up piece of hot scrap and had to drop it. Hit foot. D.
18. As two men were loading heavy runner scrap, one let his end fall, causing other man to drop his end of scrap onto his ankle. C.
19. Helper was carrying scrap when it broke in two and hit his foot. D.
20. Helper was loosening scrap in runner and struck hand against sharp scrap sticking up in runner. D.
21. Helper was claying up gate and cut hand on scrap sticking on side of runner.
22. Helper strained back in lifting heavy scrap from runner. D.
23. Helper was gathering scrap when he stumbled over a piece of scrap and cut his ankle. D.
24. Keeper punctured bottom of foot by sharp scrap cutting shoe. D.
25. Helper was breaking scrap with “mulligan,” and when piece broke, one end flew and hit fingers. C.
26. Keeper was breaking scrap with sledge, which glanced off and hit his leg, splintering bone. B.
27. As cast-house laborer was sledged scrap, piece flew into his eye. D.
28. Laborer was sledging bar held by furnace helper. Missed bar with sledge and crushed helper’s finger. C.
30. As laborer was holding bar to rid up runners, bar became wedged. Man put hand over top of bar to work it loose just as helper struck it with sledge. D.
31. Monkey boss had abscess form in palm of hand from handling bar. D.
32. Man was cleaning runners, prying hot scrap out with bar. Bar slipped, allowing man to fall forward into hot runner. C.
33. Helper threw bar down on cast-house floor, where it bounced and hit great toe. D.
34. Cinder snapper was barring scrap in runner, when he slipped and hit his shoulder on end of bar. D.
35. As man was barring heavy lump of scrap, bar slipped and fell onto instep. C.
36. Helper was lifting scrap with tongs, and when tongs slipped he fell backwards over wheelbarrow. D.

Accidents 16 to 36 were due to unskillfulness, forgetfulness, awkwardness, or misjudgment of the men, or to established but objectionable methods of work. The latter cause is subject to immediate correction. The former can be corrected only by sustained and continued effort to encourage care and prudence in this class of work.

Three men were overcome by heat while cleaning runners, and a fourth was overcome when running iron at cast. These accidents occurred in May, July, and September, months when periods of hot or sultry weather are encountered. As a rule, heat is not so difficult to withstand during a cast as during cleaning of the trough and runners, because with the sides of the cast house open and the almost universal ventilator in the cast-house roof, the heat is rapidly carried off when the iron is running, and, moreover, the heat is dry, in contrast to the moist heat frequently encountered about the runners. In addition, while a crew is running a cast, they only
infrequently have to approach or work close to the runner, whereas in cleaning the runners after a cast they have to work practically on top of the runners or troughs. These are always very hot and are frequently steamy, and when the cast has been a hot, limy iron, there is always a “heavy clean-up” on account of the excessive amount of scrap left in the runner. Owing to the length of the runner, fans are impracticable.

Most cast houses are all that can reasonably be desired in arrangements for admission of fresh air and escape of heat. Cast houses recently built are improved in that the fall or slope of the runners is much greater than in cast houses where iron was previously run in beds, also because the runners are much shorter from the skimmer to the first ladle junction. These changes lessen markedly the amount of scrap and the work necessary to remove it; hence the chance of injury or of heat exhaustion is also lessened.

An adequate and continuous supply of cool drinking water in the cast house is of assistance in reducing the liability of heat exhaustion or cramps. With water carried in pails, there is frequently excessive consumption of water every time a fresh bucket is brought in. If a drinking fountain is available, the difficulty of gulping down large quantities of water from the fountain, and the continual supply, tend to promote moderation in drinking, rather than the drinking of large quantities at infrequent intervals.

**LIFTING SHUTTERS.**

Five injuries occurred to men lifting shutters in running iron, owing to an explosion of hot metal when it encountered wet or damp sand, or possibly cold scrap when the gate was lifted and the sand worked up in the rear was pushed out or pushed aside by the iron. Disabilities of 2, 5, 18, 20, and 21 days were caused, owing to burns from flying metal.

The safest method of operating shutters is to run the iron into the ladle nearest the furnace first, and then into the next in turn, until the cast is finished. In this manner a shutter on the runner to the ladle is unnecessary, or is used only in a very fast and heavy cast, and the shutter at the junction in the main runner can be lifted by cables attached to the shutter and led over sheaves to the cast-house wall. The end is commonly placed one ladle away, on the ladle track side, down the runner. The keeper can in this position gage the fullness of the ladle above and operate the shutter at the correct time and from a safe distance. Some furnace men prefer to lead the cables to one point, near the furnace signal and lever, on the ladle track side. If a cast-house crane has been installed, overhead cables can not be used, but the cables may be led under the cast-house floor plates and attached to the shutter lever.
Devices to operate shutters from a distance can sometimes not be used if it is necessary or advisable, on account of possible need of shifting ladles, to run to the bottom ladle first. Under such conditions the gate must be dropped instead of lifted, and many times this must be done by hand, a mechanical device failing to seat the shutter against a fast run.

To avoid the necessity for anyone having to approach the junction and loosen up or bar out sand behind a shutter, it is necessary to put a foot piece on the shutter. This breaks a path for the iron by lifting the sand behind the shutter when it is lifted. To minimize the danger of flying sparks and splashes of molten iron in the event of damp sand, a shield should be placed on the lower side of the shutter to confine any spattering, as small explosions are not uncommon. If a shutter has to be dropped or thrown to divert the metal, care should be taken that it is dry. A hand shutter is usually thrown by laying it at the junction, with the gate over the runner, the handle extending back, so that the hot metal flowing beneath heats the gate up before use. Only experienced men should be allowed to throw shutters, or men who have had ample opportunity to observe how it is done, as there is a knack in gaging the throw, dropping the shutter, and turning away almost simultaneously to avoid injury from splashes. When the shutters are inserted by levers, it is essential to have the levers as long as practicable so that the men can keep away as far as possible. Care should be taken to remove all scrap from beneath the shutter, as when the shutter is dropped on heavy scrap and is forced down through it to make a tight stop, a boil may start.

Any dampness or cold scrap in a runner may start a "boil." Once started there is no telling where it will end. A boil in a sand runner has been known to eat down more than 10 feet into the fill, the boil being a continued succession of explosions, violent flames, and throwing about of hot metal and sand. In iron runners cold or wet scrap or damp loam or other lining material may start a boil that, for no apparent reason, continues to eat into the iron runner. A keeper dropped a gate on the runner and a sudden boil started. He received burns of the abdomen and was disabled for 19 days. Another casthouse employee, in running from a boil, tripped and fell, bruising his knee. He lost 4 days.

The keeper should always be sure that the trough and the runners are perfectly dry, and that no cold, heavy scrap is present before the cast is started. If loam is used to grout the runners particular care is necessary. A few plants use furnace gas to dry the runners. In using gas a good fire of kindling, coke, or waste should be started before the gas is turned on, and if the gas does not ignite at once,
it should be turned off and a hotter fire made. An accumulation of gas and air in the runners beneath corrugated iron will give a severe explosion if it is tardily lighted. As a second helper was attempting to light gas in the runner the gas exploded, burning his right ear, the side of his face, and his hand, causing him to lose nine days' time. Matches should not be used.

The practice represented in accidents 7 and 8 is hazardous in the extreme, but is sometimes indulged in when a particularly heavy or tough piece of scrap resists all efforts at breaking to size suitable for the stock house. It is better to send such pieces to the scrap drop, and blowers should forbid the putting of scrap in runners either before or during a cast unless they are present to see that the scrap is dry and warm. Putting scrap in ladles should be avoided absolutely, for, aside from the hazard, it accelerates the formation of a skull on the ladle.

Such "shots" or explosions as are illustrated in accident 9 are due to moisture and occur in the same manner as when runner shutters are operated. The best safeguard is to lift the gate by means of a lever or steam cylinder at the wall. At one plant the same cylinder is used to remove both the splasher and the punch-out gate. When this arrangement is not feasible, on account of an overhead crane, other methods to insure safety may be used.

One method is to notch the bottom of the gate, and at the end of a cast, after the removal of sand banked against the gate on the outside, the iron is drained from the trough by using a long picking rod to poke out the clay behind the notch at the bottom of the gate, the man thus being away from the trough on the cinder-runner side, in contrast to the usual position in which the helper pulls the gate up a trifle; and then, holding the lever by one hand, punches a bar through the clay or sand at the bottom to drain the iron. In the latter case the bar must be pushed through the molten iron in the trough, and the helper, on account of the angle at which the bar must be held, is close to the gate in a place where any shot may easily catch him. When this method of raising the punch-out gate and draining the trough is employed an effective guard may be used. This consists of a cast-iron plate held at an angle of about 45° by a couple of supporting plates cast on the sides. A hole is left in the center of the plate for the punch-out rod.

Another method, little in use, is to cast the punch-out gate with a round hole at the bottom. This is heavily grouted and plugged with an iron "bot." The iron is drained through this hole until cinder comes, when the hole is botted up and the gate lifted. The objection is that the gate is too frequently cut out by the iron. This objection is in itself unimportant, as far as expense of renewal goes, but there is the possibility that during a cast a leak of iron may start through,
become unmanageable, and drain more or less of the entire cast onto the first ladle and onto the yard. This development is much dreaded with any kind of a punch-out gate, and in some plants a double gate is used, seemingly with satisfaction. It goes without saying that both the inside and outside of such gates are very carefully clayed and banked up.

One advantage of this method of draining the trough is that it makes the skimming much easier at the monkey skimmer. This is usually a hot job, and there is frequently a small explosion when the sand dam is knocked out to drain the slag away and to keep it from going into the iron ladle. If the iron can be largely drained from the trough before the overlying slag comes, the separation of the slag and the iron is much cleaner and less difficult; hence the liability of accident is lessened. Probably the safest method of accomplishing this secondary skimming at the end of a cast is to replace the old-fashioned sand dam with a cast-iron dam, which can be pulled up by a lever or with a coned-out shutter, which serves the same purpose. No injuries are reported specifically as occurring at the monkey skimmer, but it is probable that at least one of eight unclassified burns received in the cast house occurred at the monkey skimmer.

Eight burns received “while casting” resulted in lost time of 4, 4, 5, 9, 15, 21, 39, and 40 days, the injuries being burns of (1) instep, (2) back, (3) eyelid, (4) foot, (5) eyeball and eyelid, (6) eye, (7) heel, and (8) foot, back, and ankle. Lack of safeguards or unsafe practice may have caused them, but five, at least, might seemingly have been avoided had the men been wearing well-adjusted goggles and tightly fitting sound shoes.

Many of the following points have already been brought out in the discussion of “accidents connected with opening of tapping hole.”

It is most difficult so to arrange a cast house that all necessity for men’s crossing in front of the tapping hole is avoided. A man should cross quickly and should avoid standing in the range of pieces of coke, hot slag, or metal that might fly from the hole if it becomes too large or starts to blow suddenly. The danger of material flying from the hole can be minimized by using two splasher plates. Their use is not as common as it should be. A further safeguard is the provision of a substantial steel-plate shield over the skimmer, or, if preferred, further down the runner, to protect the men running the iron. Such a shield is especially desirable if the shutters are in line with the tapping hole, and is well warranted in any cast house on account of the necessity of occasional passing in front of the tapping hole. The only objection to placing the shield at the skimmer is that it may deflect a burst of flame or coke on men working alongside the trough with a picking rod to open a hole.

Care should be taken to keep off from crusted slag.
Accident 1 is the only specific mention of injury caused by the use of cold bars or ladles in running hot metal. It is probable that others of the unclassified burns were from this cause. The danger of the practice is well known but new men should be informed of it.

Goggles should be worn by cast-house men while running iron and while breaking scrap.

OTHER CAST-HOUSE ACCIDENTS.

1. Machinist had hand on mud-gun clamp shaft which was being lifted with crane. Clamp on shaft slid and caught fingers. C.

2. Cast-house laborer was fastening cable about scrap; signaled craneman to hoist but kept hand on cable and was caught. D.

3. Helper was unloading clay from car with crane bucket and was caught between side of car and bucket when craneman hoisted. C.

4. Foremen was laying iron runners in cast house. Sling rope on tackle broke, allowing runner to swing about and catch man's leg, amputating it. B.

5. Machinist was holding incandescent light on extension cord, when socket short-circuited, burning his hand. D.

6. Roof cleaner on cast-house roof fell through to cast-house floor. A.

7. Laborer was helping take down chain block used for setting runners, and fell to cast-house floor. C.

8. Blower was hit in eye by spall from mushroomed head of wedge on mud-gun clamp. B.

9. Laborer stepped into loam box full of boiling loam. C.

10. Helper was scalded by steam from burning hose on hot scrap. D.

11. First helper's hand became sore and infected from using bar. D.

12. Cast-house laborer cut hand on scrap and did not report for two days. Infection. D.

13. Helper tripped and fell into hot sand of iron beds. D.

14. Pig-iron carrier, in poleing iron along runner, made misstep and fell on side of car. B.

15. Pig-iron carrier dropped iron on feet. B.

16. As pig-iron carrier was breaking iron, pig caught on apron, throwing him onto breaking block below cast-house sill. B.

17. Pig-iron carrier was walking up plank to throw iron into car when plank rocked, causing him to crush hand between iron and cast-house door. D.

18. Laborer stepped into hot sand. C.

19. Laborer got hand full of hot sand in carrying iron. D.

20. Helper was running iron in beds, when explosion occurred, throwing hot metal into his glove. D.

21. As man was loading scrap into wheelbarrow, a glove caught on scrap. D.

22. Man carrying scrap allowed it to fall onto his feet when he stumbled. D.

23. As man was wheeling scrap on wheelbarrow, piece slipped off onto foot. D.

24. As man was throwing scrap into box, he cut his knuckle and infection resulted. D.

25. Laborer, in moving clay gun, caught his finger between blocking. D.

26. Brick pile fell over onto man while he was removing brick. D.

27. Man caught foot between casting and runner. B.

28. Men were lifting floor plate onto truck and allowed it to fall onto laborer's foot. D.
29. Helper picked up hot bar and burned hand.  D.
30. Man stepped on bar and twisted his ankle.  D.
31. Laborer was swinging sledge to break scrap and strained muscles of chest.  D.
32. Laborer was wheeling wood in barrow, and piece of wood with nail in it slipped off and man stepped on it.  D.

Mention of accidents of the type of 10 to 30 might be prolonged to give many variations. As regards development of safeguards, such a review serves little purpose, for safeguards are not possible. As a rule the injuries are not serious, and in a way, such accidents might be considered a hazard of the work. The possible usefulness of a review lies in the emphasis it places on the necessity of carefulness on the part of the workmen. The majority of accidents result from handling scrap, followed in order of frequency by dropping material while handling it, and by stumbling. There can be traced no relation between the length of employment and the liability to injury from such an occupation as hand labor and the use of hand tools. Only in injuries incurred in the handling of hot bars and scrap does the term of employment appear to have any bearing. Five of six men injured had been handling less than six months.

Precautionary measures suggest the preceding review of accidents include a frequent inspection of equipment, particularly rigging tackle, cables, ropes, chains, and blocks, to see that they are safe. The supervision of rigging used can not be too painstaking; for life and limb will often depend on its strength. Each incandescent-light bulb on an extension cord should be provided with an insulated handle, away from the lamp socket, with which to grasp the light. A wire guard about the bulb should also be provided.

Men working on roofs should wear belts with safety lines. If it is not practicable to secure the end by tying it to a roof ventilator angle, some one should be delegated to hold the loose end. Especial care is necessary in walking over corrugated-iron roofs of cast houses after they have been in service for six months or more, because the steam and sulphur fumes from the furnace casts and flushes quickly rust the iron and, although it may appear substantial, it may be a mere film of iron crusted with rust. Plate roofs are preferable and are used in modern cast houses, where they are given a slope sufficient to obviate the necessity of cleaning.

Falls in the cast house over bars, scrap, and cinder can largely be avoided by keeping the cast house clean. Racks should be provided for all tools. Burned bars should be removed promptly or set along the wall after each cast, and sledges should be put away from places of work or travel. Constant effort should be made to prevent accumulation of rubbish and tools underfoot. Neatness carries with it a certain self-discipline and, whereas a dirty, cluttered-up
cast-house floor breeds carelessness and increases the liability to accident, a constant cleaning of the floor helps make men careful in other ways.

Many of the injuries resulted from methods of doing work that were relatively inefficient as regards the least effort, quickest dispatch, and maximum accomplishment. Training men to make improvement on the economic side has shown benefit in that the men take precautions against accident as their skill and alertness of mind increases. Such training sets men’s minds to work, and when that has been done the men comprising a cast-house crew, or other gang, begin to take an intelligent interest in real preventive measures against accidents.

DISPOSAL OF SLAG, FLUE DUST, AND IRON.

FLUE-DUST DISPOSAL.

Flue-dust plants, at which the dust from dust catchers and from the flue-dust stock pile is standard nodulized, or briquetted, are becoming standard equipment pilethany furnaces. They vary from simple installations to those of having considerable intricate handling machinery. The handling of flue dust causes many burns, as it may be at a temperature of 300° to 500° F.

1. Helper fell down steps, spraining wrist. D.
2. Attendant tripped over loose board, bruising arm. D.
3. Oilier removed cover over chute and failed to replace it; later stepped through it. D.
4. Laborer was on ladder when it slipped. D.
5. Foreman was leaning against railing when it gave way, and he fell to track. B.
6. Laborer stumbled and fell against hot plate. D.
7. Laborer in handling brick had abscess form on hand. D.
8. Laborer’s hand became infected from handling wheelbarrow. D.
9. Inspector was holding wedge for fellow workman to strike with sledge when head of sledge flew off handle, striking inspector on head. D.
10. Millwright’s helper was removing cupboard, when it fell over on leg. C.
11. Laborer was putting belt on pulley in motion and caught finger. D.
12. Conveyor man attempted to remove dirt from tall pulley while conveyor was in motion; hand was caught and arm broken. B.
13. Pressman in loading briquets on buggy put foot on rail; operator started buggy, crushing and breaking pressman’s toes. B.
14. Laborer in unloading flue dust burned back of hand. D.
15. Laborer in unloading flue dust slipped and fell into pile of hot dust, burning arm, neck, hands, and leg. C.
16. Laborer stepped into pile of dust along track and got hot dust in shoe. C.
17. Unloader jumped off top sill of car into hot dust. B.
18. Unloader opened drop doors of car of dust, and hot dust flew out, burning hands, neck, and face. B.
19. Laborer was pulling nodules down chute into car, when rush of material caused hot material to fly into face. C.
Beyond equipping steps with handrails and nonslip treads, it is difficult to eliminate the probability of slips and missteps. Statistics over a wide range of industries indicate that of all accidents falls down steps comprise approximately 4 per cent, and falls from ladders approximately 4 per cent, and that approximately 40 per cent of all falls are due to slipping and stumbling on the ground level. Thorough inspection of railings at regular intervals, keeping yards and floors clean, eliminating depressions and projections, and replacing or guarding manhole covers and pits is important.

Accident 9 illustrates negligence of employer in that tools should be regularly inspected for defects. Other hand-labor accidents were largely the result of lack of skill or of carelessness. The same is true of those accidents in which men were injured by machinery.

Hot flue dust will fly into the air and run on the ground to a greater extent than other material usually handled about furnace plants. It is deceptive in that it usually does not appear to be hot, and it seems to possess the property of clinging to the skin when it comes in contact with it in flying through the air, accounting for the seriousness of flue-dust burns. Men engaged in unloading hot dust should wear tight shoes with the trousers fastened about the ankles. The sleeves of coats or jackets should come down to the wrists and be fastened over the tops of the gloves. Fastenings for trouser and sleeve bottoms should be easily and quickly removable, rubber bands are satisfactory.

Men should not be allowed to jump into cars of flue dust to shovel it out, for although the top dust may be cold or damp, the interior, below a thin crust of cold dust, is often exceedingly hot.

Some adequate spraying device at dust catchers is urgent. A simple ring spray is apt to cause excessive saturation, so that the dust is unfit for use at the flue-dust plant. Consequently the dust is sometimes much undercooled, or is cooled only in sections. Spraying the dust in the car after the dust bell has been dumped is not satisfactory because the top is saturated, but the bottom and interior may remain hot. A device in use is an inverted truncated cone enclosing the spray and bell. This accomplishes the work more efficiently than any other device designed to dampen the dust only partly rather than to completely saturate it.

Walks along and over flue-dust receiving bins are preferably made of cast-iron grids, extending from the rail girder to the sides of the bins. These grids prevent men from inadvertently stepping into heaps of hot dust. One concern has a movable plate shield which is placed alongside the car-door hopper to prevent dust from being thrown out sideways in bulk when the doors are opened.
SLAG DISPOSAL.

1. Laborer, in hooking on cinder pan at cinder dock, pinched finger between hook and pan. D.
2. Laborer had hooked crane chain to slag bucket. When craneman lifted bucket it swung about and hit laborer's ankle. D.
3. Laborer was holding tongs on lump of slag while crane lifted and tightened tongs. One hook slipped off, swung, and caught laborer's finger between it and other hook. Compound fracture of finger. B.
4. Cinder laborer was using pressure hose to flush pavement and was thrown to ground by twisting of hose. D.
5. Cinder man slipped and fell over loose cinder, wrenching back. D.
6. As ladle dumper was prying "sticker" from ladle, piece fell out on foot, burning it. D.
7. Cinder man was wheeling cinder to pit and, becoming enveloped in a cloud of steam, ran barrow against obstruction and fell over barrow. D.
8. Cinder snapper was wheeling cinder up plank into car. Plank wobbled and man lost balance and fell to ground. D.
9. Scrap picker was breaking hot skull when a fragment flew onto hand, burning it. D.
10. As cinder-dump laborer was dumping cinder pots hot dust flew into his eye. D.
11. Cinder-dump laborer was prying out "sticker." When skull loosened molten cinder held in it splashed over laborer's body. B.
12. As laborer was prying out skull cinder dammed by a small piece of cold slag ran out over his leg and foot. B.
13. As pourer was operating lever to dump slag thimble slag splashed onto foot. B.
14. Cinder-dump laborer had loosened safety catch on ladle and started away from truck when thimble was dumped. Slag slopped over back lip onto man. B.
15. Laborer was cleaning up cinder mess in yard and stepped on crust of cinder. Crust broke through and foot went into molten slag. B.
16. Just as ladle that had been drained was tilted to remove or loosen skin skull chilled on side of ladle thimble foreman stepped in front of the ladle and fluid cinder held by the skull splashed over his body. A.
17. Track cleaner was working on granulating-pit track when board plug in car of granulated cinder came out, allowing hot water and cinder to run over his foot. C.
18. As laborer was cleaning cinder-ladle track man in cast house threw bucket of hot water down on his back. B.
19. Helper was wheeling scrap from cast house to stock house past cinder pit. He was drenched with scalding water from bucket of granulated slag swung from pit over runway to car. C.
20. Craneman was emptying slag from pit when steam from granulating cinder burned his face and neck. D.

Accidents like No. 8 can be eliminated by replacing single-plank runways with double-plank runways, cleated on the bottom. Most of accidents 1 to 7 are representative of the hazards of the work or illustrate lack of thought or care. Although men are not unaware of the possibility of such accidents, it requires reiteration to impress the fact that such injuries are actually impending over them individu-
ally as the result of hasty, unconsidered, or unskilful methods of work.

Accidents 1, 2, and 3 are typical hooking-on accidents. Safety hand hooks, instruction as to safe ways of holding hooks, and as to the necessity of standing clear when the hoist is made are all necessary to avoid such accidents.

A modern cinder ladle is admirably designed as regards strength and safety in transportation and in dumping. None of the above accidents can be attributed to lack of safe equipment, for suitable ladles were part of the plant equipment at all but one establishment where the accidents occurred.

Care must be taken by men to wear goggles and tight shoes when dumping hot cinder, for occasional splashes are inevitable. Before stepping on crusts of hot cinder from leaking ladles or on messes of any kind the crust should be tested with a bar.

In dumping ladles the thimble should be tilted slowly. Hand-operated ladles are necessarily poured slowly, but ladles tilted by steam require adjustment of the oil needle valve and occasional replenishment of oil, so that the throw of the piston will be braked throughout its travel. When a ladle of cinder is dumped suddenly there is almost always a big burst of gas and flame, and the liability to splash is, of course, much greater than when it is tilted slowly. A ladle should not be dumped until everyone is away, and if necessary the dumper should satisfy himself that men loosening safety catches have finished their work and are out of range of splashes especially when the ladle is dumped from the locomotive.

Extreme care is necessary in dumping ladles onto damp rubbish, refuse coal, flue dust, or ashes containing coal. Several accidents have resulted from this dangerous practice. One fatality resulted from dumping slag onto flue dust, and a nearly fatal burn resulted from dumping a ladle onto some mixed dust and coal. In such accidents there is almost an explosive burst of flame, and fluid slag is thrown surprisingly great distances. Falling slag will splash much farther than iron. The dumping of liquid slag on the material mentioned should be prohibited.

A common difficulty in dumping slag is an occasional sticker, caused by a delay in hauling or by a long haul and the consequence chilling of the cinder. Warped and cracked thimbles are especially likely to cause stickers. The most hazardous practice on the cinder dump is that of attempting to pry out these stickers without allowing time for them to become chilled all the way through, because if there is a molten center there is a probability that when the skull drops and breaks the molten contents will splash over the men prying on the skull. One such accident resulted fatally in 1914. The
cinder cools rapidly, and after 24 hours the entire contents may be safely assumed to be solid. One company requires that stickers be sidetracked at the dump for 72 hours before they can be worked on. Such a requirement tends to make the ladle gang put forth special effort to keep ladles in good condition, so that there will be the least chance of stickers, and is a requirement that keeps dangerously cracked or warped ladles off the run.

After the liquid contents of a tilted ladle have drained an occasional practice is for the cinder-dump gang to step to the front and bar out the skin skull. Usually only a few pryings with a bar are required to start this skull, and the men develop skill and agility in performing the work. However, occasional burns are thus caused, and it is better practice to jar the skull out by tilting the ladle back and forth against the frame. This procedure is, of course, practicable only with steam-dumped thimbles. The skull of thimbles dumped by hand or pushed by a locomotive should be allowed to cool, as the contraction and cracking of the cinder will often cause the skull to slide out, or lessen the chance of burns if the skull has to be pried out by hand. In 1914 a man was severely burned when he stumbled as he started to jump back out of the way of a hot skin skull that suddenly collapsed.

An occasional cause of accident is an explosion of cinder ladles. As a rule the explosion occurs when the ladle is standing at the cast house and during a cast or flush. It is caused by damp rubbish or water being in the bottom of the ladle before cinder is run into it. Usually nothing more serious than a violent boiling and splashing takes place, which, as a rule, starts slowly. When iron goes into the ladle with the cinder, however, a veritable explosion may throw the entire contents of the ladle over the yard and into the cast house. In 1914 one man received minor burns by such an explosion. Such explosions can be prevented only by carefully examining the ladles when they are spotted at the furnace, and, if they are wet or contain water, by drying them with hot cinder or a wood or coke fire. Damp rubbish should not be thrown into ladles.

Similar explosions are sometimes encountered in cinder-granulating pits, two men being seriously injured in this manner in 1913. They are caused by iron running into the pit in large amounts. Men should keep away from the pit as much as possible during a cast, and should never go near it when the skimmer is being drained at the end of a cast.

An aid to stop stray iron from reaching ladles or granulating pits is a catch basin between the main and the monkey skimmer, and the ladle or pit, which will catch iron going over the dam or iron that has been poorly skimmed. Such basins prove their efficiency by
the considerable amount of iron recovered in them, ranging from 5 to 40 tons per month per furnace.

Such accidents as No. 20 are liable to occur if the crane cab of cranes is placed over the pit. As a rule, the span of the crane girders is sufficient to allow the cab to be placed on one side of the pit. If this placing is not possible, as is true with some types of cranes, the craneman should not be allowed to run over the pit to dig up cinder while the furnace is flushing or casting into it.

Considerable necessity for work about cars of granulated cinder may be obviated by having a deflecting plate between the pit and the cars of dust. So far as possible, track cleaners should wait until the filled cars have been removed by the engine before cleaning tracks. The danger of hot water from cars and from buckets inadvertently carried overhead is thereby eliminated. There should be no pathways beneath the swing or travel of buckets handling granulated cinder.

IRON DOCK.

The iron dock, the iron wharf, and the pig-storage yard are terms designating some part of the furnace yard or the breaking platform at the base of the cast-house wall, or in the yard where the iron is loaded or stored pending shipment. The injuries result largely from handling the iron pigs by hand, though the introduction of locomotive steam cranes and lifting magnets has introduced a hazard that may cause injuries more serious than are typical of handling by hand. However, such injuries are of much less frequency.

CRANES.

1. Laborer, loading pig iron with crane and standing at end of car with hand on car door, signaled crane to move up. Crane struck car and caused door to pinch finger. D.

2. Fireman was standing with hand on brake wheel of car being loaded with pig iron, when crane operator accidentally dropped magnet on man's hand. Left hand contused and lacerated. D.

3. Laborer was collecting scattered pigs in car for magnet to pick up, and as magnet was lowered into car man attempted to pass between magnet and side of car, when he was caught by swing of magnet and crushed. Fractured hip. B.

4. Crab man unloading iron from car into yard with magnet did not see magnet swing back after it had discharged load of iron and was struck by magnet. Compound fracture of wrist. B.

Locomotive-crane engineers working in cabs inclosed in the sides and with their minds fixed on the manipulation of hand and foot levers can not give entire attention to possible hazardous positions of men working with the crane. The movements of the crane and the magnet are fairly regular and may be anticipated. Men working
with the crane should time their work to the craneman’s operation, and signal for a stop if necessary. Foremen or shift bosses should impress upon the men the necessity of keeping from under the travel of the magnet, of going to the other end of the car when the magnet is lowered and raised, and of having the crane stopped when it is necessary to collect the iron.

**FALLS OF PERSONS.**

1. Iron piler, 10 years’ experience, stumbled and fell on hand. Dislocated finger. D.
2. Iron piler, 8 years’ experience, stepped on wet spall and fell against a pile of iron, cutting arm. D.
3. Iron loader, 6 years’ experience, stepped from top of pile against iron used to hold plank in side of car. Deep laceration of thigh. D.

**FALLING AND FLYING MATERIAL.**

1. Laborer, 4 years’ experience, threw pig from car on pile, and spall broke off and flew in eye. D.
2. Laborer, 2 years’ experience, threw pig on pile, and silver flew and cut eye. D.
3. As laborer with 11 years’ experience was handling machine cast iron lime dust from pig flew into eye. Burned left eye. D.

**HAND LABOR.**

Eleven injuries to the hand and fingers were caused by hand labor. Five were caused by the men getting their fingers caught by pigs rolling or falling down a pile. The disabilities were 3, 7, 11, 19, and 20 days, caused by cuts of finger, cuts of palm of hand, loss of nail, crushed and cut finger, and crushed hand. The experience of the men injured varied from 5, 10, 24, 10, and 14 years.

Two injuries were due to piling or loading pig onto hand, resulting in crushed middle fingers. The time lost was 7 and 14 days, and the experience was “years” and 3 hours.

Three injuries were caused by striking the hand against the top or edge of a car or against another pig while carrying iron. Loss of time of 7, 7, and 15 days, caused by cuts at base of thumb and on knuckles. One man of 4 days’ experience cut his finger on a sharp edge of pig iron. Lost time, 5 days.

Nine injuries resulted when men let pigs drop on their feet when pigs slipped from hand leathers or caught on hand leathers, or a man stumbled or bumped his body or arm against some object.

Five injuries were caused by pigs rolling down from piles onto men’s feet.

One laborer who had had 10 days’ experience suffered a strain while lifting iron to load it in a car. Lost time, 13 days.
As regards such hand labor as carrying iron, it is of interest to note how prone men are to accident even after they have had considerable experience.

**PIG MACHINE, LADLE HOUSE, AND SKULL DROP.**

**PIG MACHINE.**

1. Lime man was using winch when cable tended to run off groove. In guiding cable with hand, fingers were caught between cable and drum. D.

2. Ladle man placed crane hook on lug of runner and gave hoisting signal. When hoist was made, his fingers were caught between chain and runner, and his little finger was fractured. B.

3. In tilting ladle to pour, pig-machine man kept fingers between hook and lug of ladle. Thumb and fingers were lacerated. D.

4. Laborer, in wheeling scrap in cellar of machine, slipped on wet pavement and cut lip on scrap. D.

5. Laborer in adjusting pigs that projected over side of car slipped and fell from top sill to track, spraining ankle. B.

6. Troughman, in cleaning runner, had foot on bar to pry scrap. When scrap loosened, bar fell on other foot. D.

7. Scraper was punching sticker out of molds. Pig fell out and broke and flying fragments hit man's eye. D.

8. Laborer passed under mold chain while machine was in operation. Wheel fell on head. D.

9. Carman was standing opposite chute taking car numbers while cars were being loaded. Spall flew from a pig dropping from chain to chute, and cut eye. C.

10. Pig-machine laborer was holding chisel to cut cotter pin from wheel pin or shaft. End of pin flew and cut eyeball, causing loss of sight. B.

11. Troughman got hot graphite in eye while casting. D.

12. Helper was carrying scrap from pouring end, and tore thumb. D.

13. Pourer was throwing scrap from conveyor tough, when foot slipped and he fell with the scrap. C.

14. Machine laborer was holding bar to cut sticker from mold. Helper missed bar and struck man's nose with sledge. D.

15. Ladleman was operating dumper lever and struck hand against nail protruding from controller box adjacent to lever. Infected puncture of hand. D.

16. Eye of laborer unloading lime became inflamed from lime dust lodging on the eyeball. D.

17. Hot spray of milk of lime was blown into foreman's eye from lime vats. C.

18. Laborer accidentally stepped into tank of hot limewater. D.

19. Lime man was turning off steam line at vat when foot slipped, causing him to plunge arm into vat of hot lime water. C.

20. Lime tender was stirring lime in lime box with hoe and slipped into vat. B.

21. Pig sticker became enveloped in steam cloud and stepped into hole of hot water. D.

22. Carman, in descending from casting end by ladder, was caught in projecting set screw on rear sprocket wheel drive shaft. B.

23. As helper was barring scrap from mold-chain rail beneath spout hot metal splashed on him. C.
HAZARDS AT BLAST FURNACES AND ACCIDENT PREVENTION.

24. Hand became infected beneath callous. D.
25. Iron ran into mold containing cold sticker, causing explosion that blew "sticker" out of mold into operator's shanty, hitting him on head. D.
26. Pourer was struck on hand by hot metal flying from explosion of hot metal in wet trough. D.
27. Man was pouring pig-machine wheels when mold exploded, burning back. D.
28. Pig-machine helper was burned by explosion of hot metal when it ran into cold or wet mold. D.
29. Man was cleaning up in cellar while ladle was being poured. Considerable iron ran over mold; hit water on floor of cellar and exploded. D.
30. Helper was poling iron in trough and a splash or spitting of iron burned eye. D.
31. Helper's goggles became clouded with steam. He pushed them back on forehead when a small splash of metal hit eyes. C.

Accidents similar to Nos. 1, 2, and 3 are common in iron and steel plants. Perhaps the primary cause is that the man, after making a hitch about an object, fails to keep a certain tautness in a chain or cable until the crane tightens up on the line. Care should be taken in doing this to keep the hand away from any side obstruction, and especially to keep it above the hitch so that it will not be caught or struck. When simple hooking on is being done, a safety hand grasp should be provided on the back of the hook, as injury appears to be ultimately almost inevitable when men have to grasp the body of the hook in guiding it.

In working about places that are apt to be littered with scrap and to be wet from spray water, care should be taken not to overload the barrow and to clear a path for the barrow when wheeling out scrap. No one should be allowed to walk on top of the sides of cars, as the sills are apt to be warped and crooked, causing a man to lose his balance. Barring down scrap tightly stuck to runners is, at best, somewhat venturesome. It is work that has to be done, nevertheless, and in spite of care a bar will occasionally fall when the scrap comes loose or gives way suddenly. New men should be warned and instructed in the safest way to do the work. Jumping on or pushing down bars with the feet is the most dangerous way.

Practically the only safeguard to prevent such accidents as No. 9 is a screen alongside the car track opposite the pig-machine chutes. Screens at the end of the conveyor or strands, where the pigs drop onto the car chute, are equally efficient, though they do not prevent spalls from flying out of the car when the pigs drop on top of the iron already in the car. However, they protect men working at the end of the chutes punching out stickers, where mechanical knockers are inadequate or unprovided. One man was severely injured in the eye by a flying piece from a pig that hit a manganese-steel chute.

Another safeguard that should be standard is a plate canopy beneath the mold chain, between two adjacent structural columns.
Men can pass beneath the canopy or can stand under it while watching for stickers when the machine is in operation without any danger of pigs dropping on their heads. (See Pl. VIII, A.) A rail should be placed along the rest of the side columns to keep men from going under the chain at any point except where the canopy is placed. The plate can not extend indefinitely from front to back, and to save a few seconds some men will take a short cut unless prevented.

The somewhat costly safeguards mentioned prevent only a small proportion of injuries, some of which, possibly, have not yet been encountered at many plants. The safeguards should be considered as a part of the general investment that is calculated to reduce insurance rates, not as isolated devices of problematical usefulness. A further precaution should be the requirement that men working beneath a pig machine or at the casting end, or engaged in sledging or cutting, shall wear goggles.

A safety committee of workmen, consisting of an electrical millwright or handy man, a pig-machine pourer, a cast-house helper, and a trestle, yard, shift, or "straw" boss, if they are thoroughly interested and have authority to correct dangerous practices, and are familiar with the character of such accidents, can do much to prevent accidents, not only at the pig-machine but all over the plant, as at the trestle, the stock house and the cast house. Haphazard, unstandardized methods of work, rather than carelessness, are often the essential cause of these accidents. The foreman, even more than a committee, must correct such methods of work; must show the men how to carry scrap efficiently, how to stand and swing a sledge effectively, and how to hold a bar to best advantage. Hand-labor and hand-tool accidents are said to be the most difficult to foresee and prevent. Perhaps more can be accomplished by training the force to a high degree of skill in their routine, every day work than by specializing in a purely safety campaign, as usually a capable man is a careful man.

Accident 31 emphasizes a general complaint in regard to goggles—that they become steamed and must be removed and wiped. Often the necessity of attention to the work does not permit immediate cleaning and they are cast aside. Many companies say that they have been unable to obtain goggles without this defect. If the steaming of goggles becomes insufferable, butt welders' masks should be used because the considerable number of eye injuries indicates that some eye protection is essential. If goggles are slipped over the eyes only when the wearer approaches or faces hot metal, the effects of steaming are not so noticeable.

Attention should be given the footwear of men working about casting operations. Tightly fitting shoes, without cracks, should be
worn, and trousers of wool or hard jean should come down over the tops. Leggings are feasible, but are not looked upon as necessary by the great majority of companies.

Explosions of hot metal poured into cold or wet molds are common. When the casting machine is being used regularly for each cast, there is the least danger of such explosions; but when it is used only infrequently for excess or off-grade iron, there are often noisy detonations and considerable flying of sparks, and occasionally a violent explosion occurs. Wet molds can be largely prevented if the roof over the casting machine is kept free from leaks, and in very cold weather excessively cold molds can be avoided by a coke jack or brazier under the mold chain. Flying sparks from wet or cold molds can be held down by shields over the runner spout where the iron drops into the molds, the shields being similar to those mentioned for cast-house spout junctions and punch-out gates.

The pourer’s window is best protected by a heavy screen. Trough men can only infrequently work from behind shields, though some plants have provided corrugated-iron shields having a hole through which the trough man can ravel or pole the graphite in the runners. To permit trough men to get from one side to another of a double-spout pouring trough, a crossover above the chains should be provided. Care should be taken to see that the runners are dry, and before the iron is poured any crust of cinder or coke dust on top of the iron in the ladle should be broken up, so that it will not hold the iron back and form a dam that will break through and allow the iron to pour out faster and with a greater splash than is safe. Only long poles should be used, and men should avoid as much as possible getting close to the runners, especially when the ladle is about to be tilted.

Men unloading lime should be provided with goggles with solid side pieces instead of gauze, and with no gaps at the top, sides, or bottom. A lime burn, either of the eye or skin, is apt to be severe and of long duration. Valves for lime vats and lime sprays should be so placed that they can be operated from beneath the mold chains at a safe distance from the mixing box. It is preferable to mix the lime in a box adjacent to the lime storage bin, whence it may be run to the vats beneath the stands. This arrangement tends to promote safety and efficiency in getting a rich milk of lime with no foreign matter in it to cause clogging of the sprays, as frequently occurs when the lime is mixed in the spray vats. The mixing box should be protected with a railing and foot board. For convenience, the rail should be hinged so that it can be turned up when the vat is to be cleaned.

Holes and sewers, especially those carrying hot water, should be provided with gratings.
A. SAFEGUARDS FOR PIG-CASTING PLANT.
A, Signs posted near track; B, covered passageway beneath molds; C, fence to prevent men from taking other than the covered passageway.

B. SAFETY HOOK FOR HOISTING BUCKETS.
Sleeve A fits into notch B and locks hook in closed position.

C. HOOK OPEN.
Latch C drops and is locked automatically.
Recent pig machines have steps provided for access to the rear platform. Projecting set screws should be replaced with countersunk screws or have a guard placed about them.

Although many plants do not place rails immediately beneath the spout, thus doing away with a source of considerable annoyance, the barring of scrap from rails from beneath or the adjusting of sprays should be done between casts, when iron is not being poured.

The type of infection represented in accident 24 is not uncommon among men making frequent use of bars. It usually develops from the formation and breaking of a common water blister. Special mention should be made to the men of the liability of lost time if ordinary water blisters are neglected or unskillfully opened.

LADLE HOUSE.

1. Ladle man attached chain hook to rim skull. As chain tightened, finger was caught between hook and scrap. D.

2. Man hooked chain to scrap and, not noting that chain was about leg, gave hoist signal. Leg was caught and broken. C.

3. Ladle skuller, in dumping rubbish bucket, had finger caught and crushed. C.

4. Ladle cleaner signaled to raise bucket of scrap. As bucket was hoisted, it swung around and knocked man against ladle truck. B.

5. Laborer in car unloading scrap from bucket was struck by bucket swinging; broken arm. B.

6. Ladle man was signaling craneman to lower thimble into thimble frame of cinder truck. Kept fingers on frame, and they were crushed as thimble slid into frame. B.

7. Man standing under crane was struck when chain was pulled from beneath ladle skull and swung; fractured jaw. B.

8. Ladle skuller was cleaning ladle when rim skull fell out onto foot. B.

9. Casting-machine man was cleaning lining from ladle. Ladle was turned up and the lining collapsed and fell on him. D.

10. As laborer was raking cleanings from ladle, skull on ladle nose fell on his foot. D.

11. Laborer was sLEDging scrap when piece bounded and struck ankle. D.

12. Iron pourer was loading scrap and tore nalt from index finger by catching it on scrap. D.

13. Ladle man was prying scrap off ladle spout when bar came up suddenly, bruising groin. C.

14. Ladle liner had bar under piece of scrap which was being hoisted. Hitch slipped and scrap fell back on bar, throwing it against man's jaw, fracturing it. B.

15. Bricklayer, working about ladle pit, slipped and fell into it. D.

16. Conductor was making cut on ladles while men were cleaning ladle into quenching pit. Explosion occurred in pit, throwing hot water and metal over conductor. D.

17. Ladle-house man was pulling cleanings into chills, when iron drainings exploded. Eyelids and face burned. D.

18. Pig-machine helper was chilling ladle cleanings with hose and was cut and burned by explosion of hot metal. D.
19. Ladle liner turned furnace gas into ladle to dry lining. He then dropped burning waste into ladle and gas exploded, burning him. D.
20. Torch exploded, burning men working on ladle lining. B.
21. Laborer had piece of hot ladle scrap fall into glove. D.
22. As extra man was cleaning ladle, spark flew into eye. B.
23. As laborer was cleaning ladle, molten iron dammed in ladle by kish ran into shoe. B.
24. Ladle cleaner stepped into quenching pit filled with scalding water. B.
25. Crane operator was burned by fuse blowing out on switch. C.

The two "hooking-on" accidents are typical. Personal carefulness will prevent such injuries, as there is little or no hazard in such operations if the workman knows of the possibilities of danger and exercises reasonable precaution.

Short bars should not be used in skulling ladles, until rim skulls and loose brick have been knocked or pulled out, as they are apt to fall, when men are close up working on bottom skulls or daubing the nose of the ladle.

A safeguard to prevent accidents like No. 15 might be provided. The ladle pit is, as a rule, set with its top flush with the ladle-house floor. By extending the wall of the pit and providing a coping 18 or 13 1/2 inches thick by perhaps 2 feet high, some protection would be afforded and no handicap to relining would be interposed. Ample light over these lining pits should be provided.

Accidents such as 1 to 15 can not be much reduced, even by the making and enforcing of rules, for such work is only slightly amenable to rules. Successful accident prevention must be obtained by largely arousing the interest of the men, directly or indirectly, in their work by inviting them to solve plant problems of operation and safety devices.

Quenching pits, that is, pits filled with water into which ladle scrap and kish are dumped are largely coming into use. Several explosions have occurred, not necessarily explosions resulting in injury, though of some violence. The reason for the use of the pits is that contact with water causes the cleanings to granulate, so that they can easily be forced through an ordinary ore-bin door, whereas the solidified skull of iron and graphite obtained by pouring ladle cleanings onto the ground or into chills, even after breaking, is so rough that it sticks in a bin. This advantage is so marked that these pits have undoubtedly come to stay. Consequently, they should be made as safe as possible; a large volume of water is necessary. The capacity of the quenching pit should be at least equal to that of the ladle from which the cleanings are dumped. Two hundred cubic feet is a safe minimum, and some plants have pits with twice to ten times this capacity. So long as the water is in large excess, explosion can not occur when hot metal is beneath it, the chilling effect being sufficient to retard the speed of the steam or hydrogen forming reaction. However, in
spite of large water capacity, the circulation of water is usually re-
tarded and large amounts of hot metal may be, in contact with
small amounts of stagnant water, because the ladle cleanings drop
into a bucket, submerged in the water, which obviously retards the
currents of water from starting circulation throughout the pit and
may permit a rapid formation of steam in contact with the hot iron.
The pit bucket should have a capacity of 150 cubic feet, and should
run down into the pit on a short skip incline, be submerged in the pit,
and be automatically dumped. With this arrangement, without ex-
penditure of labor or the use of a crane, the bucket can be dumped
after each ladle is cleaned, and the accumulation of scrap in the
bucket can be avoided as well as the contact of a large amount of hot
iron with a small amount of water. If it is necessary to grapple for
the ball of the bucket and to hoist the bucket into cars by an overhead
crane, there is a tendency to allow a dangerous accumulation of scrap,
the bucket not only becoming full but the scrap getting near the sur-
face of the water. The pit should be provided with a heavy steel
shield behind which the men can work, because occasionally heavy
cleanings may be carelessly permitted to rush into the pit and may
cause minor or possibly serious explosions. Bars and rakes of the
longest practical length should be used. Side railings are advisable.

Explosions of gas while it is being lighted in ladles to dry them
can be avoided by dropping a bunch of oily waste or burning paper
in the bottom of the ladle before turning on the gas. Explosions
of torches are usually caused by setting the torch on a hot surface,
scrap, slag, cleanings, or plates.

Accidents like others mentioned can be largely avoided by using
long bars in breaking up hard kish and skulls in starting to drain
the ladle. After rim skulls and the loose cleanings have been re-
moved, close work with short bars and sledges does not involve any
marked risk, so long as the men wear goggles or masks. The ground
or chills should be perfectly dry.

Accidents like accident 1 are purely a hazard of the work.

All fuses on mill circuits should be inclosed, or put where they
are not in range of men working nearby.

Cranemen and crane oilers, upon coming on turn, should make a
daily inspection of their cranes for loose tools, bolts, or other mate-
rial that might fall off. To locate loose nuts of bolts requires a thor-
ough examination, and it can not be expected that such defects will
always be noticed, any more than it is to be expected that men will
happen to be under cranes at the precise moment when a bolt or
other part drops. However, daily inspection by the craneman, with
an occasional regular detailed inspection by an electrical millwright,
will minimize the chance of such injuries.
Injuries caused by pinching of the hands in handling ladles, or equipment, like most injuries in which men are caught in simple machinery, are not to be foreseen. After such an accident the injured frequently can not tell why or how he got caught. If men injured in this way are rightly handled by their foremen after they return to work, they can usually be converted into careful workers and active safety men for a time. To keep them interested requires effort.

**SKULL DROP.**

Though a skull drop is operated at all furnaces having iron ladles, it is difficult to segregate skull-drop or skull-cracker accidents at furnaces and steel plants and to definitely apportion them to furnace operations.

1. As scrap breaker was pulling chain to release ball at skull cracker, chain pulled apart, having previously broken and been mended with wire, against orders. Cut of scalp. D.

2. Craneman, in coming down ladder from cab, slipped and fell 30 feet to ground. Fractured wrist, bruised head, knee, and shoulder, and internal injuries. B.

3. Turn man started to pull pulley block off track, but as he grasped the cable the engineer started the hoist and drew turn man’s hand into block. End of little finger amputated. C.

4. Laborer had eyes blinded and burned by excessive light from arc burner. D.

5. Laborer was working at scrap drop when molten iron from a piece just broken ran into water and exploded. Burns of neck, side of face, elbow, and wrist. D.

6. Ladle-house man was helping break scrap at skull cracker. In running hoist, craneman raised and stopped bucket too suddenly and caused scrap to fall off bucket onto head and shoulders of ladle-house man. Cuts and burns of scalp and shoulder. C.

7. Laborer working in scrap yard was struck by flying piece of scrap broken off by drop ball. Loss of sight of right eye. B.

8. Laborer was loading scrap on car at skull cracker and let piece fall on foot. D.

9. Laborer helping at scrap yard hooked crane hook onto scrap bucket, and signaled cranemen to hoist. He was holding hook on clevis and when crane lifted, bucket swung, catching foot between bottom of bucket and piece of heavy scrap near pile. Cut and wrenched ankle. D.

The standardized safeguard about a skull cracker is an inclosure on all four sides, built of reinforced concrete, concrete-filled steel pipe, or timbers, with an opening for the cars. At all plants, except a few where the breaking of furnace scrap is done in a ladle or the cast house, the operator is provided with a sturdy steel-plate shield, or with a cage inclosed with screens or bars. A rope or cable is preferable to a chain for releasing the ball, and should extend outside the drop inclosure. The ball man should be protected when he trips the catch. As a further measure of protection, signs
with a white "Danger" on a red background should be placed on each side and at all approaches.

The personal element is a large factor, as the outline of accidents shows. Loading and hooking on of the crane and other hand labor offer plenty of opportunity for the cooperation of the men in reducing the number of injuries after the management has provided all reasonable safeguards around the skull drop.

**GAS-MAIN SYSTEM, GAS CLEANING, AND STOVES.**

**GAS-MAIN SYSTEM.**

1. Bricklayer's helper, working on temporary platform on gas main, fell to ground. D.

2. Boilermaker's helper fell from platform in making repairs at dust catcher. D.

3. Rigger, in bolting manhole head on gas main, slipped and fell to ground. D.

4. While handling brick on top of hot-blast valve chamber, laborer slipped and fell to pavement. D.

5. Boilermaker's helper was changing bell at dust catcher. Scaffold he had built gave way, and he jumped to ground. D.

6. Carpenter overloaded platform on which he was working, causing it to give way. Fell 8 feet. C.

7. Flue-dust man, standing on plank across top of hopper car, was cleaning downleg chute. Plank broke, throwing him to the bottom of car. C.

8. Laborer's neck was burned by hot dust while he was cleaning downleg. C.

9. Laborer was cleaning gas main. Board on which he was working sank into dust, causing burns of ankle. C.

10. As yard laborer opened bell on downleg, dust flowed over leg. B.

11. Laborer was on wall next flue dust car and, thinking dust cold and hard from watering 15 minutes previous, jumped into car, sinking foot into flue dust. B.

12. Labor foreman had men cleaning under dust catcher. Ordered men from beneath, as the bell had to be bumped. Just as the bell was lowered, foreman sprang back beneath catcher to recover shovel and was caught in shower of hot dust. B.

13. Rigger allowed wrench to fall from main; it struck top of laborer's head. D.

14. Laborer was struck on head by brick from gas-main platform. D.

15. Man was holding cutter on rivet, when head flew up and hit eye. D.

16. As man was tearing scaffold from dust catcher, he punctured his hand. Neglected to report, and infection developed. D.

17. Rigger was swinging connection into place on gas main. Shackles broke and piece swung about, knocking man to ground. B.

18. While rigger was changing hot-blast valve, an explosion of gas in hot-blast valve chamber burned him. B.

Accidents 1 and 2 could have been avoided if wooden or rope railings had been provided on the temporary platforms. Walks and railings placed along the tops of the mains would have prevented accidents 3 and 4.
Accident 5 shows that only carpenters should build temporary scaffolds. Accident 6 should not have happened as the injured man was presumably in the position to know the strength of the scaffold.

Accident 7 is a common type in yard and track work. An inspection committee can locate the defective or inadequate planks, and it is also strictly the business of labor and turn foremen to look out for such unsafe planks.

With the exception of the two accidents last mentioned, the injuries are characteristically due to lack of care or skill on the part of the injured or their foremen. The construction of platforms with toe boards and the removal of loose material from high places whence it may fall, together with signs to warn men of work overhead, are safety measures needing emphasis.

From time to time breakage of rigging tackle has caused a serious accident. Inspection of this equipment, specification of tackle for a particular job by the boss rigger, and supervision of hitches and working positions of men in the gang by either the boss rigger or a careful and capable gang foreman are essential.

The foreman involved in accident 12 had had 23½ years' experience about blast furnaces, and must have been perfectly conversant with the work and with the chance he took. In spite of a safety campaign of five years' duration, the safety impulse had seemingly not been sufficiently awakened in him. Such accidents are baffling, for if foremen, supposedly of greater intelligence than their men, fail to comprehend the rudiments of a safety campaign but persist in taking foolish chances themselves, even on the spur of the moment, it is too much to expect men of less ability to grasp the idea, and it is manifestly wrong to discipline them for their failure to do so. For instance, this particular foreman would be in poor position to reprimand even the laborer who, in accident 11, jumped off into a car of freshly dumped flue dust.

Accident 9 illustrates a method of work that is better done by flushing water into the main with a high-pressure hose. Accident 8 could have been prevented by having the dust-bell lever provided with cables running over a pulley, enabling the men dumping the dust leg to stand away. Dust catchers should be similarly equipped. A clamp to prevent the bell from being opened by a slip or by excessive weight of dust is well warranted.

Explosions of gas in the main when hot-blast valve seats are being changed are infrequent. When this work is done the gas should be drafted back through the stove nearest the furnace between the valve under replacement and the furnace. Assuming the valve in No. 2 stove leaking and the No. 1 stove valve off for cleaning, or No. 1 stove valve leaking, the gas must then be drafted past the hot-blast valve chamber under repairs to a further stove. Occasionally when the hot-
blast valve seat is slid out the gas ignites explosively. At one plant, where a serious accident of this description occurred some years ago, the tuyères are plugged when a No. 1 stove seat must be changed.

Some plants experiencing excessive cracking and leaking of valve seats have replaced the bronze water-cooled seat with solid cast-iron or steel seats. The author does not know whether their use has proved successful. Pressed and welded water-cooled seats are successfully used.

STOVES.

1. Laborer was on top of checkers cleaning same when gas escaping from burner asphyxiated him. D.

2. Rigger was caught between bracket and stairway in construction. A.

3. As hot-blast valve was being hoisted, block broke, allowing valve to fall on man's head. B.

4. Hot-blast counterweight cable broke, allowing weight to fall on man's shoulder. B. (Accident happened in 1914.)

5. Millwright, working on scaffold at hot-blast valve, fell when scaffold broke. D.

6. Helper fell from top of hot-blast stove. No witnesses. A.

7. Laborer beneath checker arches was hit on foot by pipe falling from hands of top cleaner. D.

8. Laborer was in bottom of stove when piece of brick fell through checkers onto head. D.

9. Laborer picking up brick outside stove was hit on lips by brickbat thrown by man working inside. D.

10. Hot-blast man was struck by mixing-valve wheel falling off stem owing to loose nut. C.

11. In 1914, laborer was in combustion chamber loading brick into bucket for repairs to checkers. As bucket was hoisted, brick fell over side and fractured skull. A.

12. Hot-blast man strained side pulling on valve winch. D.

13. Stove cleaner, carrying cover plate on top of stove, had toes crushed when eyebolt broke off. D.

14. Rigger, in rolling hot-blast valve along pavement, ran valve over foot. C.

15. Stove tender slipped on pavement, straining ankle. C.

16. Stove repair man crushed hand between doorframe and thumb nut in closing stove door. C.

17. Bricklayer's helper in cleaning checkers was struck in abdomen by gas pipe he was plunging up and down to dislodge brickbat in plugged checker. Peritonitis from perforation of intestine. A.

18. Millwright burned eyes by hot dust from packing gland of hot-blast valve stem. Was packing gland with blast on furnace. C.

19. Man burned hand in screwing light into socket, socket short-circuiting. D.

20. Stove tender turned steam into pipe to blow out checkers. Hose burst and steam scalded body. B.

21. Hot-blast valve burst on account of steam pressure being too high. Steam was used to thaw out valve. Helper scalded. D.

22. Laborer was cleaning stoves, and as dust was scrapped outside stove, hot flue dust flew into his eye. D.

23. Mason's laborer, in wheeling flue dust, stepped into pile of hot dust. D.
24. Pipe fitter's helper opened door of stove to see whether gas was burning, when gas flashed back, burning his face and forearm. D.

25. Gas ignited suddenly at burner door just as stove tender stepped near to observe whether it was burning. Explosive puff blew dirt in his eye. D.

26. Cionder snapper was through for day and was standing in front of stove, when door clamp broke and escaping hot blast blew him against side of adjacent stove. A.

27. Stove cleaner was cleaning stove well when a slip in the furnace threw dust and flame from the bottom cleaning door. D.

28. Stove cleaner had been inside cleaning checkers, and had come out for a breath of fresh air. A slip in the furnace next to the stove caused the man to fall off the stove. A.

The danger of asphyxiation from gas while men are working in stoves is chiefly from leakage of gas from gas valves. Minor dangers are as follows: From gas working back into the stove when the furnace is off and the gas is being drafted back past the hot-blast valve to a stove beyond the one being cleaned; from leaky burners or mains of adjacent stoves; and from gas turned into the stove by an inexperienced stove tender. As the nose of the gas burner is within a few inches of the doorframe of the stove when the stove is off gas, and as the burner nearly always leaks slightly, it should be turned on its seat 90° away from the door, or there should be a blank put in between the burner base and the rack, or between the burner and the interior seating valve, or the stove burner door should be shut. In addition it is advisable to tag or lock the hot-blast valve, as well as the burner valve. Excessive leaks from near-by burners or downlegs should be plugged.

Stove counterweights should be inclosed. (Pl. IX, A.) Counterweights should hang close enough to the ground so that this may be done. Many counterweights are suspended extremely high, and present a difficult proposition, and auxiliary cables are practically the only means of holding these up if the main cable breaks.

Stove tops should be adequately railed, with a toe board of 12-inch plate at the foot. They are preferably made of angle iron not less than 2 by 2 inches by ¼ inch, and with at least one intermediate railing. If made 4 feet high, there should be two intermediate rails. Access to dome cleaning doors at the top and to checker cleaning doors beneath the main platform should be by railed steps if possible. When not possible, the necessity for climbing over the top of railings to gain access to ladders should be eliminated. This fault is common in many stoves. Each ladder should be arranged so that a man can step off from the top platform directly to the ladder and descend with his back to the shell of the stove. Manholes on top of domes of two-pass doors should be provided with platforms. Such equipment is necessary because of the great height of the stoves, and because of the possibility of men being partly gassed and dizzy.
A. GUARD FOR STONE COUNTERWEIGHT.

B. VALVE LOCK AND DANGER TAGS FOR BOILER.

A, Hinged metal case, painted red, for locking valve stem; B and C, danger tags; D, boiler number.
Railed platforms at the hot-blast valve seat and at the top of the hot-blast valve chamber are standard construction on newly erected plants. If these have not been installed, a collapsible scaffold support of light angles and flats, with plank to furnish the flooring, is a time-saving device, and safer than a carelessly erected platform.

The danger of injury from brick falling from the top of the stove through the checker openings is practically eliminated if the stove cleaners enter the top first, open and brush all checkers, dislodge disintegrated and loose checker brick, and come out before men go under the checker arches to remove flue dust and brick débris. In tearing out skin walls and brickwork, liability of injury from tumbling or flying brick from the doors is minimized by hanging a steel plate a few feet in front of the door.

The mention of fatal injury is made because this kind of accident was formerly not uncommon during the relining of furnaces and stoves. It is almost universal practice now to build a substantially covered scaffold about 7 feet high in the bottom of the combustion chamber when a skin wall is being built. There is an opening provided for the brick bucket. As a rule, brick for repairs to the top of the checker are hoisted from the outside of the stove and offer little possibility of injury aside from handling.

Gloves should be worn when one is screwing electric-light bulbs into sockets.

Only approved wire-wrapped three-ply steam hose, purchased as such, should be used for blowing out stove checkers or boiler tubes, and it should be tightly clamped onto a steam union with corrugated pipe extension inside the hose.

As a rule, hot-blast valves and seats, as well as other bronze furnace-cooling equipment, are designed for use only with low pressures. High-pressure water or steam is, therefore, to be used with caution.

Flue-dust injuries about stoves are, of course, eliminated if washed gas is used. In wheeling dust, care should be taken not to fill the barrow too full. Stepping in dust is well known to be dangerous, and injuries from this cause are due to carelessness. All dust should be promptly cleaned up. Wetting it is even somewhat hazardous, for if a heavy stream of water is turned on it, it will fly surprisingly.

Stove cleaners should always wear goggles.

Every man should be instructed not to open stove doors, nor to go near them, when a stove is on gas. Only stove tenders and cleaners should be allowed to open the doors. for they are more apt to know whether the gas is liable to flash on account of excessive gas, dirty checkers, or poor drafts.

It should not be necessary for an experienced stove tender to look into a cleaning or air door to see whether the gas lights, as it will
either light promptly at the nose of the burner, back in the well, or
if it lights only at the top of the well there will be a puff. If the gas
does not light promptly, it should be turned off at once and a hotter
fire of waste should be provided. When the stove is full of gas a
very explosive ignition may take place.

Other characteristic injuries from slips about stoves are: Broken
leg from jumping off hot-blast valve to escape slips, sprained wrist
from fall while running to escape a slip, and bruised head and back
from material from slip.

If furnaces do not have closed tops, a signal whistle at least 2½ or
3 inches in size should be placed at the top of the trestle. It should
have operating wires for use by the stock-house men, who usually
know when a furnace is hanging, and for use by the furnace blower,
who can usually determine closely when the furnace is about to slip
if the blast is not checked, or, if he has to check the furnace, can give
ample warning.

If the furnace is slipping badly and more than one check is neces-
sary, time should be given stoke cleaners to come out of the stove
because gas may draft back into the stove. A stoke cleaner should
come out from a cleaning door away from the furnace, and to avoid
uncertainty the door facing the furnace should be marked on the
inside with red chalk, as confusion is easy inside the stove. Stove-
well cleaners should be warned away from cleaning doors also. It
is safer to clean the wells with the burner shut off, as otherwise
there is likelihood of a burst of gas when the furnace slips. The
warning whistle is the only whistle necessary about the furnace
stack, and even where the blowing-room whistle is audible all over
the plant, a special warning is essential.

One hazard about stoves is the breaking of bolts or door yokes
when the stove is on blast. Such breaks occur without warning;
consequently, men must not be allowed to stand in front of stoke
doors. Neither must stoke tenders be allowed to tighten nuts on air
inlets, or on burner doors to stop air leaks while the stove is on blast.
It is equally dangerous to loosen or partly open blow-off valves
before closing the cold-blast and the hot-blast valves. The practice of
excessively tightening thumb nuts on various doorframes before put-
ting a stoke on blast is almost as bad as tightening them after the
blast is on, for as the doorframe and the door heat up when the blast
is on, an increased strain is put on the bolts which, if the elastic
limit is repeatedly exceeded, will ultimately fail. Cast-steel door
yokes are in some plants replaced with two small structural-beam sec-
tions, which are considered much more homogeneous and less liable
to conceal hidden defects such as blowholes or segregations.

A locking device for valves about a boiler is shown in Plate IX, B.
This device is used as a protection to a man entering a boiler. At
one plant when a man enters a boiler two steam valves, two feed valves, and the blow-off valves between the boiler and the main headers are each closed and securely locked by the device (A) shown, which is a hinged metal case, painted red, that is slipped over the valve handle and padlocked. A metal tag, B, reading “Danger, man in boiler,” is attached to each case. A small tag, C, reading “Danger, man on machine,” is attached as an additional precaution. All boilers are distinctly numbered both in front and in rear, the crown valve on top of each being numbered correspondingly with a metal plate, D. This number can not be effaced and prevents possible confusion leading to the operation or locking of the wrong valve.

GAS-FIRED BOILER HOUSE.

1. Boiler tender was mudding up clean-out doors on dust leg and stayed in gas too long. Asphyxia. D.

2. Water tender, in changing gas burner, was overcome by gas. D.

3. Helper was working on top of boiler setting and was overcome with gas. D.

4. Water tender, in trying to stop leak in gas burner, was overcome with gas. C.

5. Fireman was in combustion chamber cleaning it. Became gassed and fell into hot clinker. B.

6. Fireman was found asphyxiated on top of boiler setting. A.

7. Boiler-house laborer was inside setting cleaning dust out and was asphyxiated from gas from leaky burner. A.

8. Carpenter working on scaffold in boiler house was overcome with gas and fell to floor. A.

9. As water tender was throwing coal through fire door, gas flashed out of furnace. D.

10. Boiler cleaner was blowing tubes, when furnace slipped, causing flame to blow out. C.

11. As scaler was cleaning setting beneath tubes, dust fell onto hand and arm, burning them. D.

12. Foreman put high-pressure hose on flue dust, causing it to fly and burn arms. D.

13. Boiler cleaner stepped into flue dust inside boiler. B.

14. Foreman stepped on plate over ditch. Plate tipped and leg went into hot water. D.

15. Scaler was cleaning tubes when the blow-off valve was opened, allowing steam to burn scaler. D.

16. Fireman had cleaned fire and pulled ashes from ash box. In spraying ashes nozzle came off hose and the steam suddenly generated burned him. D.

17. Fireman was cut by bursting gage glass. D.

18. Water tender was scalded and cut by bursting water glass as he turned water in after replacing defective glass. B.

19. Pipe blew off steam hose, scalding man standing beneath. C.

20. Water tender was scalded by bursting tube while blowing off dust on tubes. B.

21. Water tender fell into ditch containing scalding water beneath blow-off line. C.
22. Water tender, not being able to see on account of escaping steam, fell into uncovered blow-off ditch, lacerating leg. B.

23. Laborer was on steam line between boiler house and engine house, painting, and fell, breaking hip. B.

24. Ladder slipped, throwing boiler cleaner to the floor. C.

25. Laborer, working on top of boiler, made a misstep and fell to pavement. B.

26. Millwright fell down steps from top of boiler setting. C.

27. Fireman was firing boiler while men outside were throwing coal onto pile inside house. Lump struck leg. C.

28. Man was struck by board falling from roof truss. D.

29. Man was moving portable scaffold when plank fell off trestle onto foot. D.

30. Eighteen hand-labor accidents of the same characteristic type repeatedly presented occurred, causing disabilities only four of which were in excess of 14 days. Lack of skill or caution was a contributing factor in each.

The less serious accidents from gas were, with one exception, to men outside the boiler setting and were due to gas leaks about the clean-out doors or burners. However, the chief cause was leaky burners, these leaks as a rule being developed by the abrasion of the iron by the sharp coke or ore dust carried in the furnace gas. As soon as a hole is worn through a burner, especially if the seat becomes eroded and gas starts to escape, the burner should be changed at once, for claying up or cementing the hole is only a temporary expedient and the gas will soon be escaping again. Thus, not only is the boiler-house force exposed to gaseous atmosphere continually, and is from time to time working in gaseous air while stopping the leaks, but the gas drifts up over the top of the boiler setting, and about steam valves where work is occasionally undertaken by other members of the furnace force. Previous records disclose numerous falls from pipes, ladders, and boiler tops as the result of partial asphyxia. Keeping boiler burners tight is a requisite for the safety of the boiler-house force.

Asphyxiation of a man inside a boiler setting is always due to a leaky burner, usually of the boiler in which the man is working but sometimes of adjacent boilers. When the slide burner is used, a plate should be placed between the nose of the burner and the burner opening in the setting. Single-valve burners are dangerous because the bell or the seat may be cut by flue dust sufficiently to allow dangerous volumes of gas to drift into the boiler setting from the outside. When a single interior sealing valve is installed, some provision is almost imperative for blanking off the burner between the valve and nose of the burner. If the burners can be withdrawn from the setting, a plate may be inserted.

The best interior-valve burner is one having two valves, between which a handhole or other door may be opened to the air. Thus any gas escaping past the first valve may be diverted into the house instead of going to the interior of the boiler setting. A company
operating several furnaces removes the burner bodily and clamps on a blank whenever men are required to go inside either boilers or stoves. Many companies require the burner valve to be locked shut. This practice is commendable, but does not eliminate minor leaks, which are the major cause of asphyxia inside settings. Rigid inspection and elimination of small leaks is essential. For changing leaky burners, inserting blanks into the gas-main side of the valves, or other occasional necessary work in gaseous atmosphere, a half-hour breathing apparatus is useful and is being widely adopted.

Special attention should be given to good illumination in the boiler houses. High-voltage electric lamps are standard, and in the absence of overhead mains that interfere with lighting the floor, they are preferably hung so as to cast some light on the tops of the boiler settings. When they are of necessity placed lower, it is advisable to have a light at each of the stairways leading to overhead walks, and in large plants two or more intermediate lights should be placed at the top.

Sufficient men should be assigned to boiler cleaning so that one can remain outside and give assistance if the man inside is gassed. The draft regulator or valve should be left open wide enough to induce a perceptible current of air, and doors in the front of the setting should be closed when adjacent burners are leaking, the work being done on the side cleaning doors. Men should be repeatedly warned about the danger of gas about burners, in side settings, and on top of boilers, as experience frequently dulls rather than sharpens any disposition toward apprehension of serious effect from gas. Most cases of “gassing” do not result in anything more serious than a severe headache for a few hours, involving no loss of time, and as a rule serious gas accidents at any one plant occur only at long intervals. Thus, the danger from gas is not always apparent to men even of long experience. The length of service of the men concerned in the accidents outlined above was 1 week, 4 and 5 months, and 2, 3, 4, 5, 6, 10, and “several” years.

A final cause of asphyxia is leaking explosion doors in gas mains inside boiler houses. The boiler-house gas main should be outside the house whenever possible. In 1914 one man was fatally overcome in attempting to close a door blown open by a small explosion in a gas main inside the boiler house, another man attempting rescue was also overcome. When the main is inside the house and equipped with easily lifted explosion doors, there is an almost continued leakage of gas, which accumulates about the top of the boilers, where the steam and other valves are usually situated. Such doors can safely be bolted down, and reliance placed in doors outside the house.

It is manifestly not feasible to place railings about the top of each boiler setting. One of the falls from the top of a boiler re-
sulted from deliberate foolhardiness. The work resulting in another fall would in all probability have necessitated the removal of a railing, if present. Walks from boiler to boiler should of course be railed, and it is important to have platforms at individual valves at the main steam header, or on overhead by-passes to which access is difficult. The handwheels on these valves, if of the inside screw type, should be secured with lock nuts. Some few plants have provided rails at the outside edge of the "dog house" or fore oven.

Whenever a ladder is set on an iron plate, someone must hold the base of the ladder. There is no known ladder base that will absolutely prevent slipping on smooth iron plates. It is, of course, desirable that floor plates, ditch plates, and manhole covers be cast with a checkered surface. Several plants have done away with the use of ladders in blowing boiler tubes by providing permanent platforms at the tube cleaning doors.

Falls down steps are largely due to carelessness. Plant managements can only minimize the probability of these accidents by careful construction of the stairs. (See Pl. X, A.) The following features are suggested: Non-slip treads, rails on both sides, treads not less than 9 inches wide, risers of such height that the sum of riser and the tread is not more than 17½ inches.

Ditches for blow-off lines should be covered. If changes in house equipment are necessary to permit covering the ditches they should be made.

Another hazard, not disclosed in accidents in 1915, lies in lighting the furnace gas. There is no danger in this work provided a hot fire is built on the grates before the gas is turned in. When, however, gas from a newly blown-in furnace is to be lighted at the furthermost boiler, it is also essential to place a very large amount of burning oily waste about the nose of the burner. Occasionally this gas is tardy in lighting and fills the setting before it ignites, when it catches fire with explosive violence. Men should be kept away when new gas is being brought down; the gas should be lighted only under the supervision of the furnace superintendent or foreman, and if ignition does not take place promptly the burner should be shut off at once and additional time given for the main to fill and push out air. Filling the boiler with gas is to be avoided—the gas should light easily and gently at the nose of the burner.

An explosive burst of flames from a boiler in which the gas is ignited and burning satisfactorily is exceptional. It occasionally happens when the gas is of the "calico" variety or "too hot to burn." It also occurs when the furnace slips. A whistle or light is sometimes installed to give warning of impending slips, but, as a rule, the blowing-room whistle is clearly audible in the boiler room and is taken as indicative of a slip. Unfortunately on single furnaces this whistle
A. LOCOMOTIVE CRANE, SHOWING GUARDS.

A, Rotating frame; B, swinging angle-iron bumper; C, floor plates; D, shield; E, hand iron; F, step; G, load indicator; H, extension for automatic coupler; J, coupler lever; K, warning sign.

B. GUARDS OVER FRICTION PULLEYS AND GEARS ON ORE POCKETS.

Note safety lines for stopping machinery.
is also a signal to fire coal to tide the pumps and power equipment over a possible 10-minute shutdown. At other times when a furnace is slipping, it may be so “tight” that little gas comes over to the boilers, again requiring another firing of coal. Curiously, if a slip is of sufficient violence to introduce a hazard of burning flames shooting out over a fireman there is, just prior to the slip, a momentary slacking off gas at the burners. To experienced men this sudden cessation is significant and gives them time to dodge back before a rush of gas comes. Men engaged in blowing tubes, however, are usually on ladders and can not as easily escape and should, therefore, get away from the doors at once upon hearing a check blown.

To prevent accidents from hot flue dust in boilers, it is necessary to dislodge all loose dust with a steam hose and to wet it thoroughly with a pressure hose before entering the setting. Men should not be allowed to go inside with hose to wet the clinker but should do the wetting from the outside.

Loose boards, pipes, or defective and loose roofing should be taken down from overhead. Unless a rule requiring removal of such material is rigorously enforced a surprising amount will accumulate, being left after occasional repair roofing jobs. Every plank on portable scaffolds should have a bolt dropped through a hole at the end to prevent the plank from sliding off the supports.

Many serious and fatal accidents like No. 15 have occurred. The only assurance of safety is to lock the blow-off valve when the boiler is taken off for cleaning. In addition to the regular boiler blow-off valve, each blow-off pipe should have a straightway or stopcock next to the boiler to prevent back pressure on the header from lifting the seat of the blow-off valve. If this is not installed, a blank flange should be placed between the blow-off valve and pipe flanges. To relieve pressure in the header, there should be a T in the blow-off line for each battery of eight boilers, permitting a pipe to be run up through the roof; or a similar pipe should be installed at the hot well.

Permanent gage-glass guards are not much in favor because they obstruct or interrupt a view from the boiler-house floor. When there is a special platform or walk for the water tender, this objection has no weight, and guards of wire glass should be provided. If no fixed guards are provided, gage glasses away from the usual or necessary travel should have a swivel guard that can be rotated around the glass while work is being done on the water columns, such as inserting new glasses.

A new gage glass must be inserted correctly, as the bursting of a gage glass may be due more to improper packing and the glands not being in line than to defects in the glass. Care must be taken that water-column valves are in alignment so that the glass can expand
freely. Glands should be screwed down tight enough to set the packing and should then be loosened slightly so that the glass can be turned with the fingers. There will be a slight leakage of steam which soon stops as the glass becomes heated. The glass should not bind the gland. In turning on the new glass, the water valve should be opened, first slowly, until the glass is filled, when the steam valve may be opened. For closing valves because of breakage, a desirable safeguard is the use of pendent chains or rods on valves operated by levers.

The number of accidents such as 19 would be lessened by the use of three-ply wire-wrapped steam hose and of a strong, tight clamp for clamping the hose to the steam pipe, and by weekly inspection of the equipment by the boiler-house foreman.

**BLOWING ROOM.**

1. Assistant engineer was in basement filling water-seal valve and was overcome with leaking gas from engine intake. Foreman in rescuing him was also overcome. D.

2. Oiler in basement getting supplies of oil was overcome with gas. D.

3. Oiler working about inlet valve of gas engine, which was shut down, became gassed and fell. C.

4. Repair man was passing under power-house crane when craneman ran blocks all the way up, breaking cables and allowing blocks to fall on man's back. D.

5. As millwright was putting casting on "spares" pile, craneman let casting down on his foot. D.

6. Electrician on crane repairing it neglected to pull safety switch. Craneman moved crane or trolley and amputated end of finger. D.

7. Laborer was dumping bucket and caught fingers between ball and bucket. C.

8. Painter glazing windows from swing scaffold was told to raise scaffold to allow crane to pass. Through misunderstanding painter lowered it again; crane upon return struck scaffold and threw him to floor. B.

9. Lineman was painting conduits when rung of ladder broke, throwing him against switchboard, where he received burns from contact with live part. D.

10. Oiler in cleaning incandescent globe was burned by globe breaking. D.

11. Electrician was cutting socket off end of electric-light wire when current short-circuited, burning palm. Had not turned off current, though switch was within 3 feet of work. D.

12. Oiler was wiping inlet-valve mechanism and valve hook crushed finger. C.

13. Wiper was caught by rocker arm of air valve on top of air tub. D.

14. Oiler was struck on head by ball governor. C.

15. Oiler was caught between reach rod and wrist plate of valve gear on blowing engine. C.

16. Oiler was screwing down grease cup and was struck by web of crank shaft. C.

17. Pump engineer was wiping service pump and scratched hand. Did not report, and infection developed. C.

18. Machinist, in carrying sheet iron past flywheel in blowing room, in some way caught sheet in wheel, twisting it against wrist. D.
19. Oilier was using bar to move flywheel to get crosshead in position. Engineer turned on steam to assist, causing quick throw of wheel to fling bar against oilier. D.

20. Pump engineer caught finger in link of valve gear of pressure pump. D.

21. Engineer caught sleeve on cam of gas engine while adjusting igniter amputating thumb. B.

22. Second engineer was wiping eccentric rod and caught hand between eccentric strap and main bearing cap. B.

23. Blowing engineer put hand on crosshead to feel whether there was any looseness and caught hand between crosshead and bottom of cylinder stuffing box. D.

24. Engineer was on bed frame of condenser engine to fill grease cups on eccentric, when foot slipped and he was struck by crank. D.

25. Laborer was washing hands under the drip of exhaust pipe on auxiliary boiler wash-out pump, when pump was started. Scalded body, thigh, and arm. C.

26. Pump tender, while in basement with torch, fell and spilled burning oil over hand. D.

27. Rigger, in repairing engine, had waste stuffed in sleeve at wrist to prevent oil running up sleeve, and waste caught fire from torch. B.

28. Helper stepped into open trap door. D.

29. Pump engineer was walking on offset of wall of cellar and made misstep. Fell to cellar floor. C.

30. As engineer was wiping rods from platform, his foot slipped, and he fell onto water-valve handwheel. C.

31. Oilier, in wiping main bearing of blowing engine, fell into flywheel pit. C.

32. Craneman, in coming down ladder, missed footing and fell. B.

33. Millwright watching men drive key in gas-engine crosshead was struck when key broke and flew. D.

34. Fireman was drawing water at power-house spigot when icicle fell from roof on him. C.

35. Bricklayer on platform stepped back against brick pile, causing brick to fall on man beneath. D.

36. Foreman was blocking up cylinder head when blocking flew out, allowing casting to come down on foot. B.

37. Machinist, in putting cylinder head on pump, caught finger. B.

38. Millwright was on ladder pulling on pipe wrench. Wrench slipped and man fell to floor. B.

39. Laborer, in wheeling brick over plank runway, fell into hole when plank wobbled. D.

40. Condenser man, in walking up plank to engine-room door, stepped on nail in board. D.

Gas about gas-engine basements comes largely from imperfectly closing gate valves employed to shut off the gas when the engine is shut down. The seats of the valves become filled with a deposit of fine fume which prevents tight closure. In addition to such a valve there should be a water seal valve, between the gate valve and the inlet valve, which can be filled immediately upon shutting down. In addition, the air for the engine mixing valve should be taken from the outside through a main up to the mixing and inlet valve, exactly as the gas is led in. With this provision any gas leaking past the gas valve is led back to the atmosphere.
Waste-water pipes from the engine jacket and piston rod should be trapped to prevent gas backing into the basement from sewers carrying water from gas scrubbers.

Vibration of pipe or depreciation of gasketed flanges may also allow the escape of dangerous volumes of gas, and it is generally considered most advisable to provide forced ventilation in the basement. The best practice is to force air from outside the building through the basement and along the base of the engines, thence up about the bed plates into the engine room, and out through the roof ventilators. One engine room housing four gas engines uses for this purpose a 42,000 cubic foot displacement fan, which is calculated to renew the air in the basement completely every two minutes.

Every gas-engine-house crew should have instruction in the Schaefer method of resuscitation from gas and electric shock. Not less than two men should go into the basement.

A direct current of 220 to 250 volts is commonly used in mills for lighting and driving auxiliary motors. However, at steel-mill furnaces, an alternating current of 6,600 volts is common. This is transformed at one or more substations to low-voltage direct current. The only furnacemen exposed to the high current are switchboard attendants and repair men in the engine and power room. Linemen are sometimes under the necessity of working near such a high-voltage line when it is carried on poles that also carry low-voltage or telephone lines. Men should never work on lines carrying more than 440 volts unless the circuit is open. They should be sure that the circuit is open at each point from which the line is supplied with power and all three wires of a transmission line should be grounded and short-circuited on each side of a point where work is to be done. The handling of high-voltage equipment is a specialized field and none but experienced men under the direction and approval of the line foreman, or chief electrician or assistant, should do any work about such equipment. High-voltage wires should preferably be placed in underground tunnels or conduits, where there is no possibility of their becoming crossed with low-voltage wires.

Work on low-voltage systems is not dangerous if precautions are taken. When possible the current should be turned off. It is important to realize the difficulty of insulating the body so that a circuit can not be completed through it. There is no perfect insulator, though for 250-volt current a number of materials may be so considered. Floors at switchboards are usually provided with rubber mats, but for other places a dry board, free from nails, may be used. Rubber or leather gloves without metallic fastenings give protection from shock. Thin or cracked gloves, or leather gloves damp with water or perspiration, give no protection. The use of rubber tape on pliers, screw drivers, or wrenches is helpful. The
tape should cover all the metal except that part essential for work, because there is always a chance of the tool slipping or of the fingers touching an unwound part. When a workman has merely to make an adjustment he should, if possible, use only one hand.

None but experienced men should work on lamp circuits, and it is to be noted that standing on insulating material will not prevent shock or burns from short-circuited lamp sockets, exploding bulbs, or arcs between charged wires when the insulation has worn off or the cord is cut. A workman changing or cleaning incandescent globes should wear gloves, and should turn his face away from the globes. Drop lights should not be used for extension lights, but a standard weather-proof socket, attached to packing-house cord, should be used.

Safeguards would have prevented most of the falls. For instance, a trapdoor or a manhole cover can often be constructed so that three sides of the hole will be guarded when the door or the cover is up. Otherwise a portable guardrail may be placed about the hole. Railed platforms can be provided along places where it is necessary for men to walk to attend to equipment. Falls from platforms, cylinder heads or bearings can be prevented by railings, toe boards, or steps with standard safety treads. Ladders to cranes may be provided with cages.

An occasional cause of injury is falls on oily platforms or steps. It is, of course, most difficult to keep some places clear of oil, and the most that can be done is to provide checkered plates and safety treads on the steps and to prevent excessive oiliness.

Four injuries were caused by the presence of men working overhead. In construction men must often be working above other men, but in regular operating this hazard can usually be avoided. If men must work above other men, the scaffolds, platforms, or places of work should be adequately provided with high toe boards. If these are impracticable, effort should be made to shift to some other place the men above or the men beneath for the time being.

Men should be warned of the danger of flying fragments from rivets, spalls, or breaking keys when other men are sledging or cutting on steel or iron equipment.

Some one man should be given the duty of knocking down icicles. Buildings like offices, engine rooms, and shops can be equipped with steam exhaust pipes under the eaves which will prevent the formation of dangerously long icicles.

The waste of time in accidents is large. If to the time lost by each injured man were added the time of men diverted from their work to assist injured men to the hospital and the time consumed in their return and in their talk about the accident, the total loss of time from useful work would be almost unbelievable. The experience of large
companies indicates that injuries from hand labor and hand tools are decreased with the greatest difficulty, although generally the real reason for the persistence of such accidents seems to be that little systematic training is given in the moving of materials, the handling of heavy weights, in piling and loading materials, or in using simple hand tools, as the newest men are generally put to work at this rough or so-called unskilled labor. To the man in the labor gang there is presented nearly every week a job to which he is new. Perhaps no two men in the gang do the work alike. Often before he has learned the best way to do one kind of work he may be shifted to other work or may be hurt. To assign a man a job of wheeling bricks with a caution to be careful but without instruction in loading and piling is somewhat like giving him a fuse, detonator, and stick of dynamite to set off, and cautioning him to be careful but giving him no definite instructions. That skilled laborers performing work rated as unskilled sometimes get hurt only substantiates the significance of the usual desultory manner of doing the work.

Many of accidents Nos. 11 to 22 could have been prevented by suitable guards about the governor, air valve, or cam, such guards being standard equipment. All the men injured were English-speaking, 11 being Americans with experience of 2 days, "few" days, 1 month, 2 years (2), 3 years, 5 years (2), 7½ years, and more than 10 years (3).

Rules have been made prohibiting the wiping of engine parts while the engines are in motion, but such rules do not apply to engines in a blowing room because the blowing engines, pumps, and auxiliaries must be kept in operation. Although such engines are operated at slow speed, rarely making over 40 revolutions per minute, this relative slowness is often deceptive. Too much stress can not be laid on the importance of carefully instructing new men as to inherent dangers, and of bringing typical injuries to the attention of the blowing-room force so that continual work about this equipment will not cause them to become careless.

The provision of ample light is practicable in blowing rooms, if anywhere. Extension lights for use when additional light is required should be provided. The use of the common hand torch should be cut down as much as possible.

SHOPS.

1. Laborer placed chain about bell rod and signaled crane to hoist. Kept hand inside sling and got thumb crushed. B.
2. Machine man was screwing incandescent globe into socket when it broke, cutting and burning hand. C.
3. Machinist's apprentice burned fingers in pulling plug from socket. D.
4. Repair man put up temporary scaffold to repair belt. Scaffold collapsed and man fractured skull. B.
5. Millwright was pouring babbitt when explosion occurred. Face burned. B.

6. Crane runner was pouring babbitt into cable socket when babbitt exploded. Burned face and neck. D.

7. Machinist was hit by wheel from overhead crane. D.

8. Machinist's helper's toes were crushed by valve yoke, which was knocked off bench by fellow workman. C.

9. As machinist's apprentice was holding iron bar for blacksmith to cut it, a piece fell on his foot. D.

10. As blacksmith was bending steel under steam hammer, a piece flew into his eye. C.

11. Molder, breaking up tuyères, was burned by piece flying inside of buttoned shoe that did not fit the ankle. D.

12. As machinist was chipping casting, a chip broke his goggles, cutting eyelid. D.

13. Carpenter foreman was turning wood on lathe when wood flew out and struck face. D.

14. Machinist was turning casting in lathe; sleeve of jacket caught in lathe dog and bruised arm. C.

15. Machinist's helper was shifting belt by hand and slipped, striking face against belt. D.

16. Machinist's helper caught arm between pulley and belt in shifting belt. C.

17. Machinist was putting dressing on belt when hand was caught and pulled between belt and motor pulley. C.

18. Machinist was grinding tool, which was jerked, causing finger to catch between tool rest and wheel. C.

19. As blacksmith's helper was grinding burrs from bar, his thumb was jerked against emery wheel. C.

20. Molder had splinter in finger and had fellow workman remove it. Finger became infected, and he had his own doctor treat it. Finally, after four months, he reported to works hospital, when finger had to be amputated.

21. Helper was moving casting. It struck and crushed lighted torch, and flames burned arm and face. D.

22. Accidents from hand labor and hand tools occur in the shop as elsewhere, typical causes being falling ladders, foot caught, falling or dropped material, and misuse of tools.

When men are handling bulbs or working on electrical equipment about furnaces, the wearing of gloves will prevent many injuries from electricity.

Common sense in the use of switches would have prevented accident 3.

Forms into which Babbitt metal or lead is to be poured should be entirely free from moisture. They should, in addition, be heated so that they are perceptibly warm to the touch. Cold iron or steel, though seemingly dry, has sometimes caused explosion. Warming can be done with a slight fire of kindling, with glowing coals or coke, or with burning gas. If a form has been prepared and then left standing before the metal is poured careful examination should be made to see that the form is dry. A mask of fine-mesh wire is an effective protection for a man pouring babbitt. This is similar to a welder's mask and covers the entire face. Goggles cover the eyes but do not protect the face.
HAZARDS AT BLAST FURNACES AND ACCIDENT PREVENTION.

Overhanging gears, or split gears, with the exception of armature pinions, should not be used on cranes. If the use of such a gear can not be avoided, the shaft should extend beyond the hub of the gear for a distance equal approximately to the diameter of the shaft, and the key should be locked in place to prevent the gear from working off the end of the shaft.

Goggles used in chipping or in work about steam hammers, etc., should be selected with especial care. The lenses should be the strongest obtainable, and should be set in deep-grooved rims so that they can not be driven through. One accident of the type of accident 12 will bring goggles into disrepute, when the many cases in which injury is prevented will get little if any publicity.

Many injuries to the toes can be avoided by furnishing shoes at cost through the storeroom. Certain manufacturers are specializing in especially stout shoes with rigid box toes. These protect the wearer's toes from injury from falling planks, bars, moderately heavy plates, or small castings which ordinarily cause painful injuries.

In regard to emery wheels, clearly it is not the much-discussed bursting wheel that causes accidents, but wheels that have been unevenly ground down, are out of true, or have poorly adjusted tool rests. These wheels should, of course, have tapered sides and large heavy safety collars, and should be provided with hoods. Such wheels offer little danger from bursting; the hazard comes from unskillful use.

Specialists have suggested many safeguards for machine shops, such as the use of safety set screws, safety collars, belt guards, special devices for wood machine tools, emergency stops, and provision for oiling line shafting, with which furnace managers, foremen, and machinists are now largely familiar. Bringing of this equipment up to present accepted safety standards is an easy way of reducing accident-insurance costs. Automatic belt shifters, safety dogs, and guarded gears and transmissions would have prevented many of the accidents mentioned, though it is to be noted that even with machine tools, which can be most fully guarded of any equipment about furnace plants, accidents due to inattention persist.

YARDS.

1. As rigger was pulling board up on scaffold, hitch slipped and rigger lost balance and fell. B.

2. Rigger, in attempting to fasten snatch block on jack pole while it was being hoisted, caught finger. C.

3. Man was guiding rope on niggerhead of hoist. Rope slipped, and as man was getting turn on safety cleat, line got away and became tangled, and man was drawn into niggerhead. B.

4. Laborer held rope too long and had hand cut on niggerhead. D.
5. Laborer had hand on casting being hoisted, when slings slipped, catching hand. D.
6. Bail of bucket fell on ashman’s finger. C.
7. While machinist was making adjustments to hoist engine, engineer allowed engine to run to lower bucket. Machinist’s finger and thumb cut off. B.
8. Laborer was running electric-burning machine and eyes became inflamed. D.
9. Trespasser (boy) climbed pole to 6,600-volt line and was electrocuted. A.
10. To escape a shower of coke when furnace slipped, laborer ran to shelter and cut forehead on overhead obstruction. D.
11. As second helper was walking to cast house he was hit on head by coke from furnace slip. D.
12. Laborer was hit on head by material from furnace slip. D.
13. Blower was standing outside cast house watching furnace when it suddenly slipped. Limestone lump struck him on head. B.
14. Six men were caught in a shower of material from a furnace slip, receiving bruises and burns. Four D and two C disabilities.
15. Sweeper was attempting to recover shovel from fellow workman and was knocked down in the scuffle. D.
16. Laborer slipped on piece of coal and turned ankle. D.
17. Laborer stumbled over brick and bruised shoulder. D.
18. Carpenter fell overboard, striking elbow. D.
19. As laborer was wheeling brick over depression on plank, plank turned and he fell 4 feet. Bruised shoulder. D.
20. Laborer fell off plank in walking over ditch. Bruised hip and foot. C.
21. As pipe fitter was walking down plank to yard feet slipped. Sprained foot. D.
22. Laborer fell down steps at entrance. Sprained ankle. D.
23. Electric inspector, coming down from platform, slipped and fell 12 feet to yard. Sprained ankle. C.
24. Locomotive engineer was hit by corrugated iron falling from roof. Confused back. D.
25. As laborer was sliding brick down chute one fell out and hit him on arm. C.
26. Laborer was unloading brick from barrow when brick fell from platform overhead. Cut forehead. D.
27. Brick worked loose from top of wall and hit rigger on head. Cut. C.
28. Laborer was digging ditch with pick when slag flew up, striking knuckle. D.
29. Shoveling ashes, sprained side. D.
30. Lifting concrete slab, sprained back. D.
31. Stepped in hole, sprained leg. D.
32. Stepped on coke, sprained ankle. D.
33. Lifting bag of cement, strained back. D.
34. Stepped on nail, punctured foot. D.
35. Carrying board, lacerated hand. D.
36. Dropped timber, great toe bruised. D.
37. Caught under shaft, fingers cut. D.
38. Dropped casting, bruised toe. D.
39. Rolling timber, contusion of toe. D.
40. Throwing plate on pile, toe contused. D.
41. Putting plate on ditch, toe fractured. D.
42. Rail fell off truck, instep crushed. C.
HAZARDS AT BLAST FURNACES AND ACCIDENT PREVENTION.

43. Timber slipped from hand, toe crushed. B.
44. Angle iron dropped, fractured both great toes. B.
45. Picking down clay, cave-in. Bruised chest, back, and hip. D.
46. Catching brick at bottom of chute. Compound fracture of middle finger. B.
47. Handle caught on side of doorway. Sprained wrist. D.
48. Barrow upset and fell from runway with man. Head cut. C.
49. Barrow upset. Index finger crushed. C.
50. Foot slipped, causing fall and upset of barrow. Fractured bones in two fingers. C.
51. Holding barrow on wagon, was thrown onto ground. Leg bruised. C.
52. Crowbar slipped from shoulder. Bruised instep. D.
53. Holding bar to cut concrete, dropped it on toes. Contusions. D.
54. Moving girder with bar and let bar fall on foot. Loss of nail on great toe. D.
55. Moving hoist engine with jack, jack slipped and handle cut forehead. D.
56. Cutting handleather. knife slipped. Laceration of inside of thigh. D.
57. Hit with sledge while holding bar. Contused instep. C.
58. Cutting peg with hatchet and cut fingers. B.
59. Steam from leaky throttle condensed in exhaust pipe of hoist engine and blew out as man stepped past. Scalded right arm. D.
60. Six men stepped into holes filled with hot water. Two D, three C, one B.
61. Two disabilities from heat prostration. Both D.
62. Pulling weeds. Rash on entire body. D.
63. Two cases of infected blister on palm from use of tools. Both D.
64. Wrenched ankle; did not report injury but rubbed liniment on it, raising a blister which became infected; foot and leg swollen. Reported after 9 days. D.
65. Small cut on little finger. Injured did not report injury but treated cut with carbolic acid. Infection and gangrene of little finger. B.

The yard injuries caused by “Playing,” “Falls,” “Falling and flying objects,” “Hand labor,” “Hand tools,” and “Infection,” have been reviewed as briefly as possible. These injuries are typical of accidents in which the personal factor plays a predominating part. Some unpreventable accidents are a hazard of the work, and are to be expected. However, injuries caused by protruding nails, steam and hot water, infection, falling objects, and falls caused by debris in the yard are preventable, as has been demonstrated by many companies. These causes of injury are particularly amenable to correction by safety committees, as contrasted with accidents in connection with rigging, blasting, running hot metal and cinder, or work with electricity, which must be prevented largely by the foreman in charge.

Aside from covering with guards the cranks and connecting rods of hoisting engines, placing guards about any gears, placing the exhaust where no one can be scalded, and bringing power cables, or steam or air pipe overhead to the temporary locations, not much can be done in the way of safeguarding winches and hoist engines. The safety cleat used in connection with niggerheads is a useful de-
vice, as it enables the man to take a turn of the rope and keep control of heavy material being raised or lowered, when not enough turns have been taken about the niggerhead. In the main, however, accidents with this apparatus result from haste, carelessness, or unskillfulness. The work requires experience to develop skill and few not conversant with it are competent to suggest safe methods. Rigger foremen are best fitted to supervise such work, to eliminate dangerous methods of work, and to devise safe methods. Such foremen should realize the peculiarly responsible position they occupy in this regard, and, welcoming any suggestions from safety inspectors or committees, should take it upon themselves to correct dangerous practices.

The danger of using an electric burner has been so repeatedly pointed out by every furnace man that there is little reason for those concerned not knowing the chances of injury. In accident 8, the injured man, a non-English-speaking foreigner, took it upon himself to try the burner during the noon hour.

If a high-voltage line is carried outside of the plant, it is well to provide beneath the line a platform, access to which is through a locked trapdoor. A similar protection may well be provided inside a plant.

There are several types of safety switches that will prevent accident.

Modern furnaces are nearly all equipped with bleeder valves which either totally prevent any material from being thrown out, or permit only the gas and fine dust to escape, thus partly relieving the pressure generated at a slip. Many furnaces constructed prior to 1902, and some built since, still have two to six easily opening explosion doors which permit red-hot coke, limestone, and ore lumps to be thrown hundreds of yards when a heavy slip takes place. Furnaces thus equipped should have signals provided by which men may be warned of an impending slip. When an explosion door faces a pathway, road, or plant entrance in nearly constant use, it is sometimes feasible to fasten the explosion door shut with a safety bolt of such size that the door will open only on excessively violent explosive slips, where relief is required to avoid blowing off the top or splitting the shell. Some plants provide shields in front of explosion doors facing frequently traveled parts of the yard, or fronting on trestles where the men may be caught inside cars if a sudden slip occurs.

TRACKS.

1. Ball of sand bucket fell on laborer's back. D.

2. As bucket was lowered into car, it bumped end door, causing it to fall on laborer's foot. D.

3. Foreman in stepping from car to crane, had foot on drawhead just as crane backed. Crushed foot. D.
4. Laborer in holding crane hook under car coupling had finger pinched when hook was pulled. C.
5. Laborer had hand pulled into sheave-hook block. C.
6. Laborer was caught between crane bucket and side of car. C.
7. Crane fireman had foot caught between boiler bed and truck frame of locomotive crane. Was getting on just as the crane swung around. Foot crushed. B.
8. Ladle helper tripped on rail. D.
9. Cinder snapper caught heel in guard rail. C.
10. Dust-catcher man stepped on rail and slipped. C.
11. Laborer was on top of coke car getting fuel, when engine bumped car, throwing man to ground. C.
12. Laborer standing on top sill of car tossing brick fell. C.
13. Laborer stumbled over piece of coke. D.
14. Laborer slipped off icy plank. D.
15. Laborer, pushing loaded track truck, slipped on loose coke and fell. C.
16. Ladder broke, allowing rigger to fall from cast-house wall to track. D.
17. Scaffold broke, allowing laborer to fall into empty car, crushing chest. A.
18. Brakeman was struck by pig iron falling from end of car. D.
19. Laborer was struck by cinder falling from passing ladle. D.
20. Laborer was struck on foot by limestone rolling down from stock pile while being loaded with crane. D.
21. Laborer unloading lumber had plank fall on foot. B.
22. Trackman was straightening spike on rail, when spike glanced. D.
23. Laborer was removing ladder from scaffold, when hatchet left on scaffold fell on foot. C.
24. As laborer was unloading ties, helper allowed his end to fall. Tie struck laborer on thigh. D.
25. As handy man was unloading pipe from car, a pipe fell on his shoulder. B.
26. Laborer was using pinch bar to move car when bar slipped, causing him to fall. D.
27. Laborer was opening drop door on car of slag. Door flew open suddenly, causing car wrench to fly about and knock hand against car frame. C.
28. Laborer was pulling spike from track, when spike puller slipped and he fell. D.
29. Track laborer hit foot with sledge. C.
30. Laborer hit fingers with hammer. D.
31. Three laborers were burned by flue dust in shoveling it or unloading it. All D.
32. Laborer was burned by cinder splashing from passing ladle. C.
33. Track laborer stepped on crusted cinder from cracked ladle and broke through. C.
34. Cinder snapper ran water on hot cinder that was escaping from defective ladle; water struck iron and exploded, burning face. B.
35. As laborer was standing near ladle at cast, iron splashed on body. D.
36. Brakeman was uncoupling ladles at hot-metal scales and was at the coupling bar, when hot metal splashed over side of ladle. C.

Familiar dangerous practices of working about buckets without lowering or securing the bail, of standing near end doors, of hooking on, and of grasping cables near the sleeve block are repeated. To prevent accidents like No. 7, a clearance of 18 inches should be pro-
vided between the frames. In 1914 two men were killed by the overturning of locomotive cranes at plants where outriggers and rail clamps were provided but not used. Some cranes are provided with electric indicators to warn cranemen when the crane tips to such an angle that further loading will result in overturning. Injuries caused by men being caught between buckets, magnets, etc., and side obstructions while attempting to steady hoisting units before they are let down can be avoided by providing hooks by which the men, working from a safe distance, can steady or stop the swing of equipment.

Stepping on rails in crossing tracks was responsible for five other minor injuries; tripping on rails caused one other injury. Coke along the tracks, insecure ladders, and working without scaffolding are causes that may be eliminated in great part.

When pig iron is loaded, all stray pigs should be removed from the end frames and sides. Ladle-house and cast-house men should remove all large accumulations of scrap from the noses of ladles, and avoid overloading cinder ladles with loose cinder-runner skulls, and should not throw them in so that ends project over the sides. Men should be warned to keep away from cars being loaded or coupled or in transit about the yards.

The danger of handling flue dust and the precautions to be observed have been previously mentioned. Ladles of cinder and metal should not be filled higher than 9 inches from the top, and yardmen should be instructed to keep away from ladles in transit. Brake-men can lessen the hazards of splashes by adjusting couplings of ladles and engines or cars before the coupling is made. The practice of standing close to the sills or frames of road cars to observe whether automatic couplers engage is unsafe when loaded cinder or iron ladles are being coupled. When such ladles are being spotted at scales, at mixers, or pig-casting machines it is usually necessary for the brakeman to stand holding the coupling lever while the ladles are uncoupled; consequently the engineer should use special care not to pull away or to stop abruptly.

Leaks in cinder ladles are nearly always due to cracks, or to iron settling in the bottom and eating through the iron or steel thimble. In attempting to chill leaky cinder ladles with a hose, the workman should remember that iron may be present, and should keep at a safe distance. When it is necessary to venture over cinder in the yard, it is safest to test the surface with a bar or to throw a plank or piece of corrugated iron on the crust to avoid breaking through.

Cracking is the most prolific cause of leaks and of stickers in cast-iron thimbles. Cast-steel thimbles are stated to be relatively immune from cracks.
RAILROADS.

1. Laborer was helping haul coke dust on railroad truck and in walking alongside truck he hurt foot on rail. Bruise. D.

2. Laborer was pushing hand truck with casting on it and wheel ran over foot. Crushed great toe. D.

Foot injuries can be prevented by guards running along the side of the wheels close to the track. This equipment is standard. When heavy material is being unloaded from trucks on tracks the wheels should be blocked because the men have to place or brace their feet close to the rail, and are not unlikely to put their foot on the rail.

3. Laborer was pushing truck loaded with sand bucket; bail fell, crushing middle and third fingers. C.

Bails of buckets should either be put down, provided with a safety catch, or blocked in position.

4. Trackman missed hold and fell in trying to get on moving locomotive. Foot bruised. D.

5. Trackman was closing hopper door, when chain broke, causing man to fall on knee. D.

6. Laborer was tightening brake wheel and caught finger. Laceration of thumb. D.

7. As machinist attempted to jump from moving locomotive crane, foot caught, throwing him and straining his leg. D.

8. Conductor was poling car when pole broke and knocked hand against frame of car. D.

If feasible, it is often safer to pull a car with a cable rather than to push it with a pole.

9. As handyman was climbing over cars he fell and injured knee. C.

10. Locomotive-crane engineer slipped and struck shoulder against throttle of crane, starting engine; foot was drawn into gears. Compound fracture of three toes. B.

11. Brakeman was riding on footboard of locomotive when it derailed, jarring man off and amputated his foot.

12. Brakeman standing on footboard of engine was talking. He carelessly placed his left hand on drawhead when couplers engaged in coupling car. Fingers contused and cut. D.

13. Laborer jumped on footboard of locomotive to ride and was squeezed between car and locomotive as they went about a sharp curve. Bruised hips. D.

14, 15, 16. Three brakemen injured hands while coupling, injuries varying from thumb bruises, with loss of 3 days, to compound fracture of fingers and burns, in coupling a cinder ladle. B.

17. Conductor was placing car of sand at furnace; car slid when brake was applied, striking concrete wall and catching man's hand between brake wheel and wall. Amputation of finger. B.

18. Laborer was placing his car under crane at cast house but it got beyond his control and bumped into an empty, causing a load of cast-iron plates to skid forward against his feet while he was attempting to set the brake. Left foot crushed. B.
Train crews should not make flying switches. Heavily loaded cars should be spotted by the engine, and should not be uncoupled until they have been brought to a full stop.

19. Cinder man, standing on ladle, was claying cracks when cars broke loose from locomotive putting them on track and bumped the ladle, throwing man to track. Ladle truck passed over arm, crushing same so as to require amputation. B.

20. Millwright was crossing track in front of a string of empties just as the engine bumped them. End car, not being coupled, jumped forward and knocked man down. D.

21. Pig-machine laborer stepped from side of building directly in front of a locomotive running light. Laceration of scalp and bruises of legs, arms, and body. C.

22. Laborer was coking ladles from the yard and stepped backward directly in front of an engine. A.

When a path leading across railroads, exits from doors, or buildings close to railroad tracks presents any hazard of injury from moving cars or locomotives, a railing should be placed so that the approach of men to the track will be retarded sufficiently to compel them to take thought of the possibility of approaching cars (Pl. X, B). When a car is to be switched into a track where men are working on cars or ladles, the men should be warned. Men thus engaged should protect themselves by placing a temporary flag in the tracks back of the switch, so that train men will know that they are in position to be injured. When a locomotive is about to move, or is approaching the ends of buildings adjacent to the track, ends of cars on adjacent tracks, crossings, or any place where workmen are engaged along the track, the bell should be rung. The whistle should be used only for urgent warning. Continuously ringing bells or whistles used for any other purpose than for warning or communication soon come to be disregarded as warning signals. In crossing tracks, men should be instructed to keep at least one car length from the end of a string of cars on the track.

23. Brakeman standing on car struck head against beam as car passed under overhead trestle. Contusion and laceration. C.

24. Brakeman attempted to jump string of coke cars being pushed up yard to furnace trestle, when hand iron pulled off, and man fell under moving train. A.

25. Crane helper was acting as brakeman on ore car which crane was pushing. Fell from the car in unknown manner, and on account of steam, locomotive crane engineer did not see him fall or note his absence until both car trucks has passed over his legs. A.

Few safeguards can be used on railroads about furnace plants. Signs, illuminated at night, showing places of close clearance and telltale ropes at each side of overhead obstructions are essential safeguards, as is a 4-foot fence or railing extending from the cor-
ner of a building and in front of a doorway adjacent to the tracks. Parallel throw switches, guard rails, switch points, bumping blocks at the end of spurs, and automatic couplings on ladles and other track equipment are standard.

Great care is necessary in coupling cars. Couplers are not always uniform in style or size, brakes may be out of order, or cars may move unexpectedly. Couplings should never be made from the inside of a curve. Trainmen should take sufficient time to examine equipment and to adjust couplers, drawheads, and drawbars before exposing themselves to danger in coupling and they should understand that no standing order or custom requires them to endanger life or limb. They should take especial care to familiarize themselves with the situation of overhead and side obstructions.

Jumping on or off of cars, getting in front of moving cars, to adjust knuckles, setting brakes on flying switches, or loosening tightly set brakes are duties attended with danger at all times, and they should not be undertaken when attended with unusual risk. Such work should not be undertaken on any account by members of the furnace force other than trainmen, as the hazard is much greater to unskilled men.

A crossing gate connected with a derailing device is shown in Plate XI, A. When the gate is in a position to protect persons coming toward the crossing the derailing device is thrown off the rail but when it is not in such a position the derailing device is in operating position.

**WALKS, PAVEMENTS, SEWERS, AND DITCHES.**

1. A hand hook used to regulate overhead gas valve at door of cast house was jarred off by vibration of building, and fell, lacerating scalp of man cleaning up pavement. D.

Hooks on overhead valves should be either securely fastened or taken off when not in use.

2. Stove tender was standing beneath hot-blast valve platform when a bar fell from platform, striking foot. D.

Bars and all loose material should be removed from platforms when work is finished.

3. Rigger stepped on protruding nail outside shanty. Foot punctured. D.

Some one was culpable in leaving such dangerous material about. Everyone should take time to flatten protruding nails or to remove boards or scrap lumber in which nails protrude.

4. Man coming through subway slipped on ice at entrance. Strained shoulder. D.

5. Millwright going home fell on icy steps over tracks. Severe bruise and sprained elbow. C.
A. Crossing gate with derailing device.

B. Handling brick by roller conveyor, safely and efficiently.

C. Car shifter with piece of hardened steel inserted in heel. When one corner of steel becomes worn it can be driven out, turned, and another corner exposed.
In the winter the yard foreman should detail a man to sprinkle salt or ashes on icy walks and steps or to remove ice altogether.

6. Laborer, helping to test cooler plates outside of cast house, let one fall over on his foot. Severe bruises and cuts of toes. B.

The need of especial care in handling heavy castings should be emphasized among members of the labor gang.

7. Rigger's helper was standing in front of exhaust pipe from hoisting engine; engineer started hoist, causing hot water and steam to blow over helper's leg and arm, scalding them. B.

Although the injured man and his fellow workman were each careless, the management was negligent in not having the exhaust discharge guarded or in some inaccessible place.

8. Foreman was pushing scrap down chute from pavement to stock house when he fell down scrap chute into stock house; fractured wrist. B.

Carefulness and the use of safety gloves or hand leathers would lessen the chance of such accidents.

9. Laborer cleaning out hot well was overcome by gas from gas-scrubber discharge, backing up in sewer. Asphyxia and nausea. D.

10. Laborer went into sewer to clean it when explosion occurred which blew hot flue dust over him. Burned face, hands, and wrist. D.

A man working in any sewer or in any well connected to sewers carrying discharge water from gas-cleaning equipment should use every precaution. Half-hour oxygen breathing apparatus should be worn. No open lights or torches should be employed, but guarded electric lights with weather and moisture proof sockets should be used. Ventilation is usually most difficult and stringent precautions, watchers and relief hands should be employed, and the work done under the supervision of a foreman.

11. As laborer was digging in a ditch a board fell and struck him on face and hand. D.

12. Foreman was standing alongside of ditch when it caved in, causing him to fall. Bruised thigh. D.

All loose débris beside ditches should be removed. The sides of ditches and excavations should be systematically tested for firmness and, if loose, should be barred down. Ditches more than 6 feet deep should be cribbed or shored up, and any excavations made in loose earth should usually be cribbed to preclude accidents. The danger is much increased in cold weather when the top becomes frozen. Whenever an excavation is being made near a track, workmen should get out when heavy loads or cars of hot metal or cinders are passing.

13. As teamster was carrying coal across ditch, plank broke, and man fell 2 feet with basket of coal. Sprained wrist. D.

14. Laborer accidentally stepped into sewer manhole from which the cover had been removed. Bruise and abrasion of thigh. D.
15. Engineer stepped into ditch, striking cheek against edge of trench. Fractured bone. D.
16. Laborer was standing on pipe while pumping water out of ditch; he slipped off and cut and bruised right leg. B.

Excavations and ditches should be protected by temporary railings or barriers; lanterns should be placed at night. Plank used for runways or walks should be of standard scaffold lumber, as cribbing or concrete-form boards are apt to be too weak for safety.

Manhole cover plates should never be left off unless the opening is protected by a sign, or portable rail, and by a lantern at night. Whenever it is necessary to work while standing on insecure footing over or near a ditch, a rope should be used for a handhold, or should be fastened about the body, if a fall or slip is liable to result in injury.

HANDLING BRICK AND CEMENT.

1. Laborer missed his footing and fell from brick pile about 18 feet high. Fractured leg. B.
2. Plank runway dropped on foot. D.
3. Brick fell from pile. D.
5. Brick pile collapsed; 2, 6, and 15 days.
6. Finger caught while taking brick from chute; 4, 3, 11, 11, and 18 days.
7. Finger caught while tossing brick; 2, 5, and 15 days.
8. Brick dropped in handling caused injuries as follows: To hands and fingers—3, 5, 14, and 24 days; to feet and toes—4, 2, 5, 7, and 14 days; to knee—1 and 9 days.
9. Strains in handling material caused disabilities of 1 and 8 days.

Rules of the United States Steel Corporation regarding the piling of brick and of cement follow:

PILING OF BRICK.

1. Except in brick sheds, brick shall not be piled higher than 7 feet.
2. The pile shall be tied at every course with alternate courses of headers and strikers.
3. When the pile is over 4 feet high it shall be tapered back from a point 4 feet high 1 inch to each foot.
4. In unpiling the taper shall be maintained.
5. Under no circumstances shall brick be piled for storage purposes on scaffolds or runways.
6. Tie strips of wood shall be inserted whenever necessary.

PILING OF CEMENT.

1. Cement shall not be piled more than 10 bags high, except in storage bins built for the purpose.
2. The first four end bags shall be crosstied in two separate tiers up to the fifth bag, where a step back of one bag on every fifth bag shall be made. Beginning with the fifth bag, only one cross tier will be necessary.
3. The back tier when not resting against a wall of sufficient strength shall be stepped back one bag to every five bags, the same as the end tiers.
4. Cement bags in outer tiers shall in all cases be piled with the mouth facing the center of the pile.
5. When cement is removed from a pile the length of the pile shall be kept at even height, and necessary step back, every five bags shall be taken care of.

Compliance with these standards undoubtedly would prevent a number of serious injuries. The use of roller tables or conveyors (Pl. XI, B) instead of chutes for brick, together with some instruction in safe ways of taking the brick from the tables, should appreciably decrease the injuries from pinched fingers. The practice of tossing brick is to be discouraged when other means of moving them are available, as injuries are bound to occur. Injuries from dropping brick on the hands and feet result from lack of skill or care, or from the hurry of the work and the fatigue of the men.

MISCELLANEOUS ACCIDENTS AROUND BLAST FURNACE.

1. Laborer was cleaning off top of gas washer and was overcome with gas. Asphyxia. D.

   Men should work in pairs at the top of gas scrubbers and there should be steps to the top. If ladders only are provided, they should be fitted with safety cages. Wearing of breathing apparatus is advisable in all gaseous places.

2. Laborer was hit on head by grab bucket when cable broke. Concussion of brain and fractured skull. C.

   If possible to avoid it, men should not get under buckets. However, they must sometimes do so, and for that reason especial attention to inspection of cable should be mandatory. The wear of cables is indicated by the breaking of the strands which, as a rule, shows on the surface. Interior wear can be determined by putting two clamps on the rope, a short distance apart, and untwisting the rope slightly, when the inside strands can be inspected.

   As the factor of safety of steel cables running over sheaves is usually 5 to 6, breaking of the wires is not serious until 30 to 40 per cent of them are broken within the length of the pitch of the strand. When a cable with 6 strands of 19 wires to the strand has 35 to 45 broken wires in a length in which the strand makes a complete whirl, the cable should be renewed.

   End hitches should be made about thimbles with three cable clamps. To avoid slipping of cable through the clamps as the load stretches and thins the cable, the clamps should be inspected and tightened if necessary.
Wear of cables usually results from crystallization of the wire, caused by high speed, small sheave wheels, or long use; from internal abrasion and wear, caused by insufficient lubrication; and from external wear incidental to use, or to rough sheaves or sheaves that are too large or too small. The best efficiency is shown when the wires do not commence to break until they are worn nearly half through.

Two cables are used, as a rule, on elevators and skip hoists, and they do not always wear evenly. If one starts to crack the most satisfactory results are obtained if both cables are changed because both will stretch evenly.

Splicing of cables for blast-furnace equipment is rarely satisfactory, as it has to be done by experts to be durable and safe.

On skip inclines there is as a rule less danger from the breaking of cables than from derangement of the skip hoist. Three safety devices which may be said to be essential are an overspeed governor, an automatic stop, and a slack-cable device.

Overspeed devices are possibly more in order on electric than on steam hoists. They are set to act when the speed of the car exceeds its normal rate; for a skip that is operated at a speed of 200 feet per minute, the speed governor is set to throw the current off and apply the brake when the speed reaches 400 to 600 feet per minute.

Automatic skip stops to prevent overrunning at top and bottom are used at practically all furnace plants. Such a stop usually consists of a revolving screw fitted with a traveling nut which engages a pinion as the skip reaches the top or the bottom. This pinion, by an arm or suitable gearing, operates relay switches or the throttle and stops the skip at some predetermined point. The automatic stops are much to be preferred to having the control exclusively in the hands of the skip operator. If adjustment is made to allow for stretching of cable, the hitting of bumping blocks and dangerous and excessive acceleration or retardation of the car are avoided.

Slack-cable devices are employed on electric hoists. Beneath the drum is placed an iron strip held by an arm which is depressed when the cable becomes slack and bears down on it. Depression of the strip causes the circuit to be broken and the dynamic brake to be applied. The device is useful in two ways—if the skip hangs at the top, over the hopper, the device will cause the hoist to be stopped before the cable has accumulated an excessive amount of slack; and if the cables have been allowed to become dangerously slack, so that the car hits the bottom block heavily and starts with a jerk as the hoist accelerates and takes up the slack, the device operates to prevent the hoist from running.

A few plants have additional safeguards—for instance, an additional cut-out device at the top of the skip incline, the device being tripped by the travel of the car beyond a certain point, and being
designed to act when the regular automatic overtravel device fails. By means of a second device an electric circuit is completed through the axle and wheels of the skip as it reaches certain predetermined points at the top and the bottom; the closing of the circuit throws on a light at the skip operator's station. This device is used where the skip operator does not command a view of the skip incline, and is an indication of overtravel, approach to bumping blocks, or of hanging or obstruction of down travel away from the dumping position. A third device is a lever resting on a skip rail and pivoted so that the front skip wheel in coming to the dumping position raises the lever and operates a telltale weight in the stock house. This device is used primarily to indicate that the skip car does not hang at the top.

3. Electrical repair man was standing at foot walk of crane with foot under line shaft, and as shaft started to turn coupling caught right roll turned up on bottom of trouser leg and pulled leg under shaft. Compound fracture of right ankle.

Couplings in line shafts should be entirely inclosed with guards that do not revolve with the shafts. Any projecting set screws should either be replaced with safety set screws or be inclosed in a guard.

4. Laborer making a coke fire threw a can of oil onto the fire. Oil burst into flame, burning hands, neck, and face. D.

Men should be emphatically warned against throwing oil on fires. As the use of common hand torches is eliminated, so that oil is less easily obtainable, the liability of this careless act diminishes.

5. Workman was working on the cast-house roof when the furnace slipped and a piece of limestone struck his head, cutting scalp. D.

With old types of furnaces the possibility of such an accident is not remote. Modern tight-top furnaces if equipped with positive closing bleeder valves remain shut against any slip and provide absolute security. Relief valves on bleeders of the free-opening type do not provide any security whatever, as scrap, limestone, and ore lumps are ejected freely through them. Explosion doors on the gas offtakes are exceptionally dangerous.

Whenever men are on top, on roofs, on poles, or in similar places from which escape is difficult, especial precaution should be taken. If the furnace is working stiffly or irregularly, and is slipping, the foreman should not allow men to go to such places, as there may be a slip even when the furnace is not known to be hanging. If the furnace is working regularly, and men are sent to such places, the furnace foreman should be notified, and especial attention should be paid to rodding the furnace. If the furnace hangs or sticks for an abnormal interval, the men should be at once warned to get under cover. If it is necessary that the men go in some place of hazard, the blower should take all necessary precautions. The blast should be taken off if necessary. If the blast is not taken off, the furnace
should be checked. Gangs working in the yard or on the trestle at such times should station a man familiar with the furnace to warn them. Under no circumstances should a man be sent to the top or to a place of similar hazard when the furnace is known to be hanging.

6. Clean-up man was changing electric light, holding wires at base of socket in one hand. The wires crossed, causing a short circuit. Burns of hand and of both eyes. D.

7. Craneman, through with work, was lying on bench reading. Had light wires across leg. Insulation was worn off and wires short-circuited, burning leg. C.

8. Craneman threw in switch and started controller to try out hoist. Threw in controller too fast, and 200-ampere fuse blew out. To escape from flame man leaned out of cab window and fell to ground. Compound fracture of elbow. B.

Fuses on all circuits should be inclosed in an asbestos-lined fuse box, or an automatic circuit breaker should be placed overhead, where the flash will not endanger the eyes. Another alternative is to place the fuse of circuits for lights, larry cars, motors, and hoists at a sufficient distance from switches or controllers to eliminate danger should they burn out. If there is anything amiss with the circuit, fuses generally blow out when the switch is thrown or the controller operated; consequently, fuses and switches should not be placed on the same base, unless the fuse is inclosed. Wire fuses made of bare metal, unless inclosed, are particularly dangerous when blowing out because of the flying of molten metal and the heat of the arc.

Wires from electric-light sockets should be taped far enough back to eliminate danger of short circuits. In general, the use of ordinary insulated wire for hand lines, extension lights, or drill motors is to be discouraged. In so far as possible, the light wires should be placed in conduits up to a given point, and standard packing house light cord should be used up to the extension handle. This handle should be of wood, with weather-proof socket. The wires from the lamp socket should not pass through a metal tube, and there should be no connection between the socket and any metal part of the holder, such as a protection cage. Gloves or tongs should be used in replacing globes. It is to be noted that it is not contact with high-voltage circuits, motor frames, brushes, or terminals that causes most injuries from electricity about furnace plants; fuses, electric-light cords, and globes cause most of such accidents. Switchboards, generators, motors, and transformer equipment are generally installed with due regard for safety. The hazards from fuses, hand lights, and cords are less obvious and consequently should be emphasized.

9. Wireman was placing trolley rail when plank on 8-foot scaffold broke, throwing him to ground. Contusion of body. C.

10. Millwright was standing on a ladder resting on a wet floor; the ladder slipped out from under him. Concussion of head and dislocated elbow. B.
11. Handy man was placing metal sheets on roof. He braced himself by placing his foot against a rod, which shook and caused him to fall 40 feet into scrap car. Skull and leg fractured. B.

12. Pipe fitter, sitting on 20-inch steam pipe screwing plug, slipped and fell 9 feet to ground. Fractured skull. B.

13. Rigger, while putting metal sheets on building, was standing on scaffold supported by block and tackle. In handling a sheet, he placed his back against building and braced his feet on scaffold; scaffold swung away from building and he fell 25 feet. A.

GENERAL REMARKS.

The foregoing review of accidents about furnace plants indicates that falls, together with railroad equipment and asphyxiation, account for most of the fatal injuries.

The standardization of scaffold and ladder equipment is admittedly difficult. An employer is in duty bound to make and enforce strict rules in regard to the construction of scaffolds—who is to build them and when and how they are to be built. The range in height of the falls noted above is 8 to 40 feet, and an injury resulting from a 9-foot fall was more severe than one from a 40-foot fall. It seems as if a standard scaffold should be provided for work at any height more than 8 feet from the ground. If the work is of a temporary character, a boatswain's chair may be used.

When a ladder rests on a smooth concrete or iron-plate floor, some one should always hold the base. For a firm wooden, brick, or dirt floor, a ladder with prongs at the bottom is safe, provided it rests squarely at the top. When long ladders, such as are used in tearing out scaffolds inside furnaces, are employed they should be made of the very best 4-inch by 6-inch pine of straight grain and free from defects; or steel ladders may be used. When ladders are used, as is necessary when furnace lining toward base is torn out, each segment should have a 1-inch hemp rope lashed to its top and the rope should be attached to a top structural column. No more than two men should ever be allowed on such ladders at one time and they should keep at least 20 feet apart. A foreman should always be present to enforce these requirements. Recently three men were working on such a ladder and all were killed when the ladder broke.

Jointed steel ladders with safety cages attached are being used to advantage for this work.

In painting or in pipe fitting, rigger, or millwright work on steam or blast lines, ladders should be employed for access to the working point, where if necessary a scaffold may be made. Many steam and blast lines vibrate considerably, and although every furnace force probably has at least one man who is so sure-footed that he can walk along such a line, the act is dangerous and should not be permitted.
Falling of men from roofs occurs so persistently that the necessity of requiring all men who work on roofs to wear belts with safety lines attached has been demonstrated. In one accident of record two men were killed by falling from a blowing-engine roof. They had not been furnished lines nor ordered to use them. In another accident a man fell from a boiler-house roof and fractured both his wrists. Ropes had been furnished and the foreman had been ordered to have the men use them, but he had not done so. His discharge followed the accident.

Falls of workers ranks fourth as a cause of accidents, accounts for the greatest number of fatalities, and results in the greatest loss of time to the workmen.

**TABULATED DATA.**

Details of the typical accidents outlined in the foregoing review and of other recorded blast-furnace accidents in Pennsylvania in 1915 are shown in tabular form in Tables 1 to 4 following:

**Table 1.—Detailed data on blast-furnace accidents in Pennsylvania in 1915.**

**Hand Labor.**

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>Total number of accidents</th>
<th>First week</th>
<th>Second week</th>
<th>Third week</th>
<th>Fourth week</th>
<th>Fifth week</th>
<th>Sixth week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Days</td>
<td>Number</td>
<td>Days</td>
<td>Number</td>
<td>Days</td>
<td>Number</td>
</tr>
<tr>
<td>Dropping material:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrap</td>
<td>21</td>
<td>15</td>
<td>4</td>
<td>3</td>
<td>9</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Pig iron</td>
<td>15</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>10</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Castings and plates</td>
<td>17</td>
<td>8</td>
<td>5</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>Brick</td>
<td>13</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>12</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Lumber</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Structural material, pipes, etc.</td>
<td>12</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>11</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total or average</strong></td>
<td>88</td>
<td>47</td>
<td>4.1</td>
<td>22</td>
<td>10.6</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Struck or pinched by material:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrap</td>
<td>13</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Pig iron</td>
<td>9</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>11</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>Castings or plates</td>
<td>12</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>13</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>Brick</td>
<td>12</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>12</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Lumber</td>
<td>7</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Structural material, pipes, etc.</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>2</td>
<td>19</td>
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<tr>
<td>Miscellaneous</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>11</td>
<td></td>
<td>1</td>
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<tr>
<td><strong>Total or average</strong></td>
<td>68</td>
<td>22</td>
<td>4.5</td>
<td>24</td>
<td>10.1</td>
<td>11</td>
<td>18.5</td>
</tr>
<tr>
<td>Strains in lifting or pulling</td>
<td>24</td>
<td>8</td>
<td>6</td>
<td>9</td>
<td>10</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>Defective shoes or sharp-edged material</td>
<td>35</td>
<td>19</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Burning</td>
<td>14</td>
<td>9</td>
<td>5</td>
<td>2</td>
<td>13</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Contact with hot metal</td>
<td>9</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Protruding nails</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>9</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total or average, hand labor</strong></td>
<td>245</td>
<td>111</td>
<td>4.4</td>
<td>75</td>
<td>10.4</td>
<td>33</td>
<td>18.1</td>
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### Table 1.—Detailed data on blast-furnace accidents, etc.—Continued.

#### Hand Tools

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>Total number of accidents</th>
<th>Time disability ended</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>First week</td>
</tr>
<tr>
<td>Struck by sledge, hammers, hatchets, or picks:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By self</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>By others</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Total or average</td>
<td>31</td>
<td>16</td>
</tr>
<tr>
<td>Struck by hand tools of others</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>Slipping wrenches</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Slipping tools of others</td>
<td>26</td>
<td>11</td>
</tr>
<tr>
<td>Strains in using tools</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Defective tools</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Car wrenches</td>
<td>34</td>
<td>12</td>
</tr>
<tr>
<td>Buggies or wheelbarrows</td>
<td>47</td>
<td>20</td>
</tr>
<tr>
<td>Total or average, hand tools</td>
<td>181</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Falling or Flying Material

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>Total number of accidents</th>
<th>Time disability ended</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>First week</td>
</tr>
<tr>
<td>Foreign body hitting eye</td>
<td>44</td>
<td>27</td>
</tr>
<tr>
<td>Material falling in or from cars and ladies</td>
<td>29</td>
<td>12</td>
</tr>
<tr>
<td>Material falling from ore chutes</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>Material flying from sledging, chipping, etc.</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>Tools dropped from elevations</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Falling timber</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Material falling from roofs or eaves</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Sliding or collapsing piles or excavations</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Falling brick:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>From linings being torn out or repaired</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>From walls, scaffolds, or piles</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>From piles collapsing</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Total or average falling brick</td>
<td>26</td>
<td>10</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Total or average falling or flying material</td>
<td>183</td>
<td>78</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

(*) Lost sight of one eye.
## Table 1.—Detailed data on blast-furnace accidents, etc.—Continued.

### Falls of Workers.

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>Total number of accidents</th>
<th>Time disability ended</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>First week</td>
</tr>
<tr>
<td>Stumbling on ground level</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Slipping on ground level</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>Falls into ditches or manholes</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Falls into or in bins</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Falls in or through cars</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>Falls from permanent platform walks</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Falls on steps</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Falls from ladders</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Breaking or tilting of plank or runways</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Stepping, slipping, or jumping from elevation</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Breaking or defect of scaffold</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Roofs</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Pipes</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Trestle</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Top of furnace or stove</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total, or average, falls of workers</strong></td>
<td><strong>154</strong></td>
<td><strong>53</strong></td>
</tr>
</tbody>
</table>

### Burns from Hot Metal.

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>Total number of accidents</th>
<th>Time disability ended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening and closing tapping hole</td>
<td>24</td>
<td>9</td>
</tr>
<tr>
<td>Operating shutters</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Sparking or splashing in iron</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Cold scrap, bars, and ladies in iron</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Water in trough</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Stepping into runners</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Cleaning runners or troughs</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Pouring at pig machine</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Using hand ladies</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Splashes from track ladles</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Skulling and cleaning ladles</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Breakouts and bursting tuyères</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Rabbot-metal explosions</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total or average</strong></td>
<td><strong>101</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>

### Cranes, Hoists, or Rigging.

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>Total number of accidents</th>
<th>Time disability ended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hooking on</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Caught in gear, rigging, blocks, etc.</td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>Struck by buckets, magnet, or loads</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Slipping or defective hitches</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Breaking or loose crane parts</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Falling bucket balls</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Defective rigging</td>
<td>3</td>
<td>1</td>
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**Table 1.—Detailed data on blast-furnace accidents, etc.—Continued.**

**RAILROADS.**

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**MACHINES OR MACHINERY.**

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</table>

**FLAMES OR EXPLOSIVES.**

| Torches | 11 | 1 | 7 | 4 | 13 | 2 | 20 | 2 | 32 | 2 | 78 |
| Flames from tuyères | 9 | 3 | 7 | 4 | 13 | 2 | 20 | 2 | 32 | 2 | 78 |
| Explosion of gas at top or at mains | 9 | 3 | 7 | 4 | 13 | 2 | 20 | 2 | 32 | 2 | 78 |
| Lighting gas | 7 | 3 | 4 | 2 | 11 | 1 | 15 | 1 | 28 | 1 | 40 | 1 |
| Oil | 7 | 3 | 4 | 2 | 11 | 1 | 15 | 1 | 28 | 1 | 40 | 1 |
| Stove doors blown off | 2 | 1 | 9 | 1 | 10 | 1 | 21 | 1 | 35 | 1 | 41 | 1 |
| Explosives | 1 | 1 | 9 | 1 | 10 | 1 | 21 | 1 | 35 | 1 | 41 | 1 |
| Total or average | 41 | 11 | 5.5 | 16 | 12.1 | 3 | 18.3 | 1 | 28 | 3 | 73 | 5 | 57.6 | 2 |
### Table 1.—Detailed data on blast-furnace accidents, etc.—Continued.

#### BURNS FROM CINDER.

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#### ILLNESS.

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#### FIGHTING OR PLAYING.

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<th>Number</th>
<th>Days</th>
<th>Second week</th>
<th>Number</th>
<th>Days</th>
<th>Third week</th>
<th>Number</th>
<th>Days</th>
<th>Fourth week</th>
<th>Number</th>
<th>Days</th>
<th>Fifth week</th>
<th>Number</th>
<th>Days</th>
<th>Sixth week</th>
<th>Number</th>
<th>Days</th>
<th>Fatals</th>
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<td>Fighting or playing</td>
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#### ELECTRICAL MACHINERY.

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<th>Number</th>
<th>Days</th>
<th>Second week</th>
<th>Number</th>
<th>Days</th>
<th>Third week</th>
<th>Number</th>
<th>Days</th>
<th>Fourth week</th>
<th>Number</th>
<th>Days</th>
<th>Fifth week</th>
<th>Number</th>
<th>Days</th>
<th>Sixth week</th>
<th>Number</th>
<th>Days</th>
<th>Fatals</th>
</tr>
</thead>
<tbody>
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<td>28</td>
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<td>1</td>
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<td>Globes or sockets</td>
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<td>3</td>
<td>12</td>
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<td>Short-circuited wires</td>
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<td>Pulling switches</td>
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<td>9</td>
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<td>Tools slipping</td>
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<td>2</td>
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</tr>
<tr>
<td>Contact with electric equip-</td>
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<td>ment</td>
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<tr>
<td>Electric burner</td>
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<td>4</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
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<td>38</td>
<td>17</td>
<td>4.2</td>
<td>12</td>
<td>11.4</td>
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<td>19</td>
<td>1</td>
<td>28</td>
<td></td>
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<td>30</td>
<td>1</td>
<td>132</td>
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### Table 1.—Detailed data on blast-furnace accidents, etc.—Continued.

#### HOT WATER OR STEAM.

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>First week</th>
<th>Second week</th>
<th>Third week</th>
<th>Fourth week</th>
<th>Fifth week</th>
<th>Sixth week</th>
<th>Total or average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stepping or falling into steam or hot water</td>
<td>27</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>12</td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td>Defective or bursting equipment</td>
<td>14</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>12</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>At clay gan.</td>
<td>6</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>13</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Steam from exhausts</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>13</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>At cinder pit.</td>
<td>4</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Water on hot material</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>13</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>Hot water or steam from tuyeres</td>
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<td>2</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>1</td>
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<tr>
<td>Uninsulated pipe</td>
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<td>1</td>
<td>2</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Mahanworking valve</td>
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<td>1</td>
<td>3</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>15</td>
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</tbody>
</table>

**Total or average:**

|                       | 118        | 14         | 12         | 10          | 12         | 5          | 31.5             |

#### SLIPS.

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>First week</th>
<th>Second week</th>
<th>Third week</th>
<th>Fourth week</th>
<th>Fifth week</th>
<th>Sixth week</th>
<th>Total or average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hit by material from slips</td>
<td>12</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>11</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Injury received while running away from spil.</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Flames from stove or boiler doors at spil.</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Total or average:**

|                       | 16         | 8           | 5           | 3           | 11         | 2          | 19               | 1 70            |

#### ASPHYXIATION.

<table>
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<th>Cause of accident</th>
<th>First week</th>
<th>Second week</th>
<th>Third week</th>
<th>Fourth week</th>
<th>Fifth week</th>
<th>Sixth week</th>
<th>Total or average</th>
</tr>
</thead>
<tbody>
<tr>
<td>At boilers</td>
<td>11</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>2 19</td>
</tr>
<tr>
<td>At gas engines.</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>1 16</td>
</tr>
<tr>
<td>At gas washers</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>At furnace tops</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>At inside stove</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Total or average:**

|                       | 21         | 12          | 5.4        |             |            |            | 4 18.5           | 1 56            |

#### HOT FLUE DUST.

<table>
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<th>Second week</th>
<th>Third week</th>
<th>Fourth week</th>
<th>Fifth week</th>
<th>Sixth week</th>
<th>Total or average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stepping into hot flue dust</td>
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<td></td>
<td>1</td>
<td>11</td>
<td></td>
<td></td>
<td>1 11</td>
</tr>
<tr>
<td>Flying or falling hot flue dust</td>
<td></td>
<td></td>
<td>2</td>
<td>18</td>
<td></td>
<td></td>
<td>2 32</td>
</tr>
<tr>
<td>Unloading cars</td>
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<td>2</td>
<td>4</td>
<td></td>
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<td>10</td>
</tr>
<tr>
<td>Rollers</td>
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<td></td>
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<td>7</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Gas mains or stoves</td>
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<td></td>
<td>2</td>
<td>4</td>
<td>1</td>
<td></td>
<td>14</td>
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<td>1</td>
<td>4</td>
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<td>Putting water on</td>
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<td>1</td>
<td>14</td>
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</tr>
</tbody>
</table>

**Total or average:**

|                       | 31         | 5           | 4.2        | 12          | 11.3       | 4          | 18.3             | 2 26.5           |

|                     |            |             |            |             |            |            | 2 32             | 6 50.5           |
### Table 2.—Data regarding duration of injuries.

<table>
<thead>
<tr>
<th>Cause of injury</th>
<th>Percentage of injuries that terminated after second week</th>
<th>Average time lost from injuries causing disability of more than two weeks</th>
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<tbody>
<tr>
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<td>Days</td>
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</tr>
<tr>
<td>Hand labor</td>
<td>24.1</td>
<td>20.8</td>
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<tr>
<td>Hand tools</td>
<td>30.4</td>
<td>51.4</td>
</tr>
<tr>
<td>Falling or flying material</td>
<td>30.9</td>
<td>51.8</td>
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<tr>
<td>Falls of person</td>
<td>45.8</td>
<td>51.9</td>
</tr>
<tr>
<td>Burns from hot metal</td>
<td>42.2</td>
<td>39.9</td>
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<tr>
<td>Cranes, hoists, or rigging</td>
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<td>39.3</td>
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<tr>
<td>Railroads</td>
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<td>39.9</td>
</tr>
<tr>
<td>Machines or machinery</td>
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<td>27.3</td>
</tr>
<tr>
<td>Flames or explosives</td>
<td>34.1</td>
<td>25.3</td>
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<tr>
<td>Burns from cinder</td>
<td>57.1</td>
<td>31.9</td>
</tr>
<tr>
<td>Illness (including infection)</td>
<td>37.5</td>
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<tr>
<td>Electric machinery</td>
<td>25.7</td>
<td>42.3</td>
</tr>
<tr>
<td>Hot water or steam</td>
<td>44.1</td>
<td>31.9</td>
</tr>
<tr>
<td>Slips</td>
<td>31.2</td>
<td>32.5</td>
</tr>
<tr>
<td>Asphyxiation</td>
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<tr>
<td>Hot flue dust</td>
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</table>

### Table 3.—Summary of data regarding causes of accidents and duration of injuries.

<table>
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</thead>
<tbody>
<tr>
<td></td>
<td>Number:</td>
<td>Days:</td>
<td>Number:</td>
<td>Days:</td>
<td>Number:</td>
<td>Days:</td>
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<td>Days:</td>
</tr>
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<td>2nd week:</td>
<td>3rd week:</td>
<td>4th week:</td>
<td>5th week:</td>
<td>6th week:</td>
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<tr>
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<td>111</td>
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<td>75</td>
<td>10.4</td>
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<td>18.1</td>
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<td>Hand tools</td>
<td>184</td>
<td>80</td>
<td>5.0</td>
<td>48</td>
<td>11.1</td>
<td>18</td>
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<td>Falling or flying material</td>
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<td>12.0</td>
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</tr>
<tr>
<td>Falls of person</td>
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<td>53</td>
<td>4.6</td>
<td>32</td>
<td>10.9</td>
<td>14</td>
<td>11.5</td>
<td>7</td>
</tr>
<tr>
<td>Hot metal</td>
<td>101</td>
<td>41</td>
<td>4.4</td>
<td>48</td>
<td>11.8</td>
<td>14</td>
<td>18.0</td>
<td>11</td>
</tr>
<tr>
<td>Cranes, hoists, or rigging</td>
<td>98</td>
<td>33</td>
<td>5.2</td>
<td>16</td>
<td>11.7</td>
<td>11</td>
<td>19.7</td>
<td>9</td>
</tr>
<tr>
<td>Railroads</td>
<td>68</td>
<td>23</td>
<td>4.9</td>
<td>14</td>
<td>12.9</td>
<td>7</td>
<td>19.6</td>
<td>3</td>
</tr>
<tr>
<td>Hot water or steam</td>
<td>59</td>
<td>18</td>
<td>5.1</td>
<td>14</td>
<td>12.2</td>
<td>10</td>
<td>15.2</td>
<td>5</td>
</tr>
<tr>
<td>Machines or machinery</td>
<td>57</td>
<td>14</td>
<td>4.6</td>
<td>15</td>
<td>10.4</td>
<td>15</td>
<td>15.4</td>
<td>6</td>
</tr>
<tr>
<td>Flames or explosives</td>
<td>41</td>
<td>11</td>
<td>5.5</td>
<td>16</td>
<td>12.1</td>
<td>3</td>
<td>18.3</td>
<td>1</td>
</tr>
<tr>
<td>Burns from cinder</td>
<td>42</td>
<td>11</td>
<td>5.5</td>
<td>7</td>
<td>9.3</td>
<td>9</td>
<td>17.7</td>
<td>6</td>
</tr>
<tr>
<td>Illness (infection)</td>
<td>40</td>
<td>10</td>
<td>4.7</td>
<td>15</td>
<td>10.8</td>
<td>7</td>
<td>15.7</td>
<td>3</td>
</tr>
<tr>
<td>Electric machinery</td>
<td>38</td>
<td>17</td>
<td>4.2</td>
<td>12</td>
<td>11.4</td>
<td>4</td>
<td>19.0</td>
<td>1</td>
</tr>
<tr>
<td>Hot flue dust</td>
<td>31</td>
<td>5</td>
<td>4.2</td>
<td>12</td>
<td>11.3</td>
<td>4</td>
<td>18.3</td>
<td>2</td>
</tr>
<tr>
<td>Asphyxiation</td>
<td>24</td>
<td>12</td>
<td>5.4</td>
<td>15</td>
<td>12.2</td>
<td>4</td>
<td>18.5</td>
<td>1</td>
</tr>
<tr>
<td>Slips</td>
<td>16</td>
<td>5</td>
<td>5.0</td>
<td>11</td>
<td>11.0</td>
<td>2</td>
<td>19.0</td>
<td>1</td>
</tr>
<tr>
<td>Fighting or playing</td>
<td>3</td>
<td>2</td>
<td>2.0</td>
<td>1</td>
<td>8.0</td>
<td>1</td>
<td>28.0</td>
<td>1</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>6</td>
<td>3</td>
<td>6.0</td>
<td>2</td>
<td>11.0</td>
<td>1</td>
<td>28.0</td>
<td>1</td>
</tr>
</tbody>
</table>

Total or average: 1,372 530 4.7 338 11.1 177 18.3 79 25.7 80 32.3 135 60.9 33

Proportion of nonfatal injuries after second week, per cent: 35.1
Duration of injuries terminating after second week, days: 34.1
### Table 4.—Summary of data regarding location of accidents.

<table>
<thead>
<tr>
<th>Location of accident</th>
<th>Total number of accidents</th>
<th>Cause of accident</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Hand labor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hand tools.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Falling or tripping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mills.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rails.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burns from hot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Causes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hoists.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rigging.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Railroads.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machinery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burns from</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Explosions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Injuries.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electric machinery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hot flux dust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asphyxiation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slip.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Miscellaneous.</td>
</tr>
<tr>
<td>Car dumper or ore bridge</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>Trestle or ore yard</td>
<td>124</td>
<td>19</td>
</tr>
<tr>
<td>Stock house</td>
<td>117</td>
<td>30</td>
</tr>
<tr>
<td>Scale car, skip, or hoist</td>
<td>37</td>
<td>1</td>
</tr>
<tr>
<td>Furnace top or stack</td>
<td>44</td>
<td>8</td>
</tr>
<tr>
<td>Blowpipe, tuyère, bosh, or</td>
<td>29</td>
<td>6</td>
</tr>
<tr>
<td>Bustle pipe</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Tapping hole or cinder notch</td>
<td>89</td>
<td>3</td>
</tr>
<tr>
<td>Runner or bed</td>
<td>78</td>
<td>6</td>
</tr>
<tr>
<td>Elsewhere in cast house</td>
<td>96</td>
<td>1</td>
</tr>
<tr>
<td>Pig machine or ladle house</td>
<td>110</td>
<td>9</td>
</tr>
<tr>
<td>Slag or fine dust disposal</td>
<td>58</td>
<td>4</td>
</tr>
<tr>
<td>Gas-main system</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>Pig iron or other storage</td>
<td>69</td>
<td>4</td>
</tr>
<tr>
<td>Stoves</td>
<td>39</td>
<td>4</td>
</tr>
<tr>
<td>Boilers</td>
<td>91</td>
<td>4</td>
</tr>
<tr>
<td>Engine rooms</td>
<td>76</td>
<td>6</td>
</tr>
<tr>
<td>Shops</td>
<td>43</td>
<td>5</td>
</tr>
<tr>
<td>Yards</td>
<td>91</td>
<td>1</td>
</tr>
<tr>
<td>Tracks</td>
<td>65</td>
<td>1</td>
</tr>
<tr>
<td>Pavements or sewers</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>1,372</td>
<td>14</td>
</tr>
</tbody>
</table>

| Total number of accidents | 248 | 154 | 101 | 98 | 68 | 57 | 42 | 41 | 40 | 38 | 31 | 21 | 16 | 59 |
PLACING OF RESPONSIBILITY FOR ACCIDENTS.

DIFFiculties Involved.

The classification of accidents according to responsibility is unsatisfactory. An absolutely correct analysis of the many factors and circumstances involved is impossible, because complete details of most accidents are lacking and because the placing of responsibility must largely depend upon the decision of the compiler as to assumptions as to fact and as to other details. An example may illustrate the difficulties. In one plant a man fell from the cast-house roof. He may have been provided with belt and line and ordered to use them, but because of some feeling of bravado may have neglected to do so. Conversely, no safeguard may have been provided. Assuming that safeguards were available, the question remains as to whether the foreman gave the employee sufficient and mandatory instructions, and, finally, the question remains as to the length to which foremen and superintendents must go. Can a foreman relieve himself of responsibility for injury to his men by giving them clear and definite instructions and by providing safeguards, or is he under obligation to follow each man to his place of work and personally see that the man continually uses the safeguards or does his work according to instructions? The cause of this accident could possibly be placed under any one of five different heads, as follows: Lack of guards, nonuse of guards, insufficient instructions, lack of supervision, or acting against rule; or, broadly, it might be classified under one of two heads—fault of workman or fault of employer.

At another plant a man was overcome with gas while changing a gas burner. The accident might be attributed to carelessness or want of skill in staying in the gas too long, to acting against a rule, to nonuse of safeguards—that is, breathing apparatus—to lack of safeguards (breathing apparatus), or to deficient plant equipment, such as lack of valve with which to turn off gas from the burner. At several plants men were severely injured in opening car doors with car wrenches. Such an accident might be classified under lack of guards, lack of skill, or hazard of the work. Lack of guards implies that some type of safety car wrench should have been employed, but similar accidents have occurred even with safety wrenches. Lack of skill implies that the employee did not have the ability to know by inspection the load on the winding stem and the car door, which is
an unreasonable requirement, but employers have heretofore claimed that such accidents should be attributed to lack of skill.

Another example is injuries that are caused by explosions of pockets of hot metal when the iron trough is chilled with water after a cast. Hazard of the work, carelessness, acting against rule, nonuse of safeguards, lack of safeguards, insufficient instructions, and lack of supervision are possible classifications for such injuries.

CLASSIFICATION OF BLAST-FURNACE ACCIDENTS ACCORDING TO RESPONSIBILITY.

A classification of the causes of accidents that has proved sufficiently comprehensive and is believed to be reasonably accurate follows:

Classification of blast-furnace accidents showing assignment of responsibility.

<table>
<thead>
<tr>
<th>Cause of accidents</th>
<th>Per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hazard of work and inevitable risk</td>
<td>29.8</td>
</tr>
<tr>
<td>2. Carelessness or lack of skill</td>
<td>14.2</td>
</tr>
<tr>
<td>3. Acting against rules</td>
<td>3.5</td>
</tr>
<tr>
<td>4. Nonuse of safeguards provided</td>
<td>1.4</td>
</tr>
<tr>
<td>5. Lack of safeguards</td>
<td>5.6</td>
</tr>
<tr>
<td>6. Insufficient instructions</td>
<td>2.1</td>
</tr>
<tr>
<td>7. Insufficient supervision</td>
<td>2.1</td>
</tr>
<tr>
<td>8. Deficient plant arrangement and equipment</td>
<td>7.0</td>
</tr>
<tr>
<td>9. Fault of fellow workman</td>
<td>2.7</td>
</tr>
<tr>
<td>10. Miscellaneous and accidents whose cause was not disclosed</td>
<td>31.6</td>
</tr>
</tbody>
</table>

The percentages are given with the reservation that the large number unclassified, if they could be properly placed, would change some of the totals materially. Most of the unclassified accidents would fall either in class 1 or class 2. It is not considered logical, on the basis of indefinite data, arbitrarily to charge the industry with a great hazard nor the workman with an undue lack of skill or care. The remaining totals would be little changed. If similar causes be grouped, the classification would be as follows:

<table>
<thead>
<tr>
<th>Cause of accidents</th>
<th>Per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard of industry</td>
<td>29.8</td>
</tr>
<tr>
<td>Fault of workman</td>
<td>21.8</td>
</tr>
<tr>
<td>Fault of employer</td>
<td>16.8</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>31.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

This classification differs radically from classifications in which 45 to 85 per cent of the injuries are attributed to the fault of the workman. In regard to “hazard of the industry,” or, in other words, the inevitable risk, it may be stated that this term is elastic, and its application to accidents at different plants shows the present state of plant conditions, equipment, and efforts to prevent accidents as the term is regarded differently at different plants. Many hand-
labor and hand-tool accidents may be assigned to this class instead of to lack of skill or carelessness. The handling of material or the use of hand tools calls for the assumption of more or less risk, owing to the fact that men can not attain a machinelike precision. At the same time most of such accidents are directly caused by clumsiness and lack of skill, and consequently their number can be lessened, and some of them are, therefore, not to be attributed to inevitable risk.

"Lack of skill" and "carelessness" are grouped together because distinction would be difficult as regards accidents not witnessed or described fully. Under this heading are necessarily included such causes as ignorance and imprudence, inefficiency and inattention, and praiseworthy and foolhardy efforts.

"Acting against rules," "insufficient instructions," "nonuse of guards," and "insufficient supervision" are closely related. "Rules" about a furnace plant could be multiplied to fill a volume. However, they largely cover certain well-understood practices, departure from which invites accident. Infraction of rules is relatively rare, and is responsible for few accidents. Accident-prevention efforts have introduced new rules, novel to a considerable proportion of the force, relating to the use of goggles, safety belts and lines, condition of tools, construction and use of scaffolds, ladders, and rigging tackle, use of safeguards, handling of electrical appliances, etc. Some of the rules and safeguards undoubtedly have been formulated and designed more as a result of enthusiasm than of specific knowledge. Some have not been adapted to actual furnace conditions and have interfered with production, and the men, therefore, have not complied with them, nor have the foremen required compliance. A feeling that little work worth while can be done without exposure to danger, and familiarity with and contempt for danger has led to disregard of other rules, and resulting accidents have been placed under "acting against rules." To what extent this cause is augmented by the tacit acquiescence of foremen is problematical, but there are sufficient data to indicate that it is an appreciable factor. Accidents in which that factor appears are included under "insufficient instructions" and "insufficient supervision," which include accidents in which men are palpably ignorant of obscure hazards or are assigned to especially hazardous jobs without the supervision or assistance of a foreman, subforeman, or capable helper. Most men resent continued supervision, suggestions, and instructions; they prefer to work in their own way. Further, it is literally impossible for a foreman to personally supervise every man's work. Also, it may be questioned whether initiative and resourcefulness are not stifled when supervision is extended too widely. The other extreme is represented when an injury occurs from lack of supervision or instructions, and such
injuries are sufficiently in evidence to indicate that instruction of men and supervision of unusual or extrahazardous work should be increased in some plants.

"Lack of safeguards" and "deficient plant arrangement and equipment" together cause 12.6 per cent of blast-furnace accidents. In regard to safeguards few furnace plant managements fail to use safeguards on account of their cost. However, at several plants there is a pronounced disposition to reject some safeguards in the belief that their use is unreasonable, that they are impracticable or inefficient, that they will interfere with the work, or that the risks involved are only seeming, not real. In the figures given, "lack of safeguards" covers accidents that would be prevented if guards in use at some plants were used. "Deficient plant arrangement and equipment" covers many accidents that might be charged to the inevitable risk of work at some plants. Practically every plant has some characteristic handicap in layout, design, or equipment to which is ascribed deficiencies in output, fuel economy, or "cost above." To corresponding plant conditions a certain percentage of accidents is due, and although such accidents are not, strictly speaking, the fault of the employer, the responsibility for the condition is his. Such a condition is, as a rule, a heritage from former days and tends to be eliminated by the demand for operating economies.

CHARACTER AND VALUE OF PRINCIPAL BLAST-FURNACE SAFEGUARDS.

The efficiency of safeguards in preventing accidents about a blast-furnace plant is not questioned, so far as is known, by operating men. However, the use of a guard often involves extra work in placing and removal, or in handling during a job, with no resultant gain in production. In contrast are certain safeguarding appliances employed in steel mills, or for wire-drawing benches and many kinds of machines. The device so used is a permanent and integral part of the machine itself and frequently results in an augmented production or efficiency.

Although many safeguards may not pay in direct financial return by preventing all of the infrequent accidents for the prevention of which they are designed, it is established that most safeguards do pay when supplemented by other accident-prevention methods. The safeguards furnish evidence of the earnestness of the company to lessen the hazards and emphasize its efforts to procure the cooperation of the force in reducing accidents. Thus it can be said that the installation of a safeguard is rarely lost effort.
HAZARDS AT BLAST FURNACES AND ACCIDENT PREVENTION.

A list of safeguards employed at various plants follows:

*List of blast-furnace safeguards.*

**CAR-DUMPER SAFEGUARDS.**

Lights at approach and discharge.
Fenders on truck wheels.
Inclosed cradle counterweights.
Steps to operator and motor house.
Electric trolley or "third rail" elevated 8 to 12 feet above yard level or inclosed in underground conductors.
Overtravel device for cradle.
Permanent railed platform about hopper of stationary car dumper.
Gong to notify operator when men are off from cradle.

**SAFEGUARDS FOR LARRY OR TRANSFER CAR.**

Fenders of the trolley-car type.
Air whistle or hand horn.
Headlights.
Air brakes.

**ORE-BRIDGE SAFEGUARDS.**

Truck-wheel fenders and guards.
Inclosed gears on drive and transmission.
Caged ladders up gantry legs.
Fireproof operator's cage.
Steps to platform of operator's cage.
Floor of cage extended to form landing platform and railing around platform.
Automatic warning bells.
Bumpers at ends of rail girders.
Rail clamps beneath trucks.
Footwalk with double railing entire length of bridge and across ends.
Main-line switch outside of cage and at each end of bridge at the trucks.
Trolley or third rail elevated or placed outside trestle work.

**TRESTLE SAFEGUARDS.**

Railed walks with outside edge 6 feet from rail and inside edge directly beneath car frame.
Crossovers from each bin to enable men to get to opposite side without jumping.
Gratings, cable, and pipe over bins between track girders. Also similar cover between walk and track girders.
Use of safety belt and line in entering bins and in unloading cars.
Use of pinch bars, each with disk on handle and tool-steel insert in heel.
Use of safety wrenches of various types.
Use of magnet to unload heavy scrap.

**STOCK-HOUSE SAFEGUARDS.**

Platform for barring ore from chutes.
Chutes provided with auxiliary heavy sluice gates to cut off flow of material.
Arrangement of levers and cables for operating chutes so that operator is out of reach of falling or flying stock.
CHARACTER AND VALUE OF SAFEGUARDS.

Bin door or chute mechanism guarded and provided with oiling platform.
Quick-stopping device for driving shafts.
Fenders, air brakes, and gongs or air whistles for scale cars.
Overhead trolley for scale cars.
Ample clearance for men on side of scale car or recesses in walls at intervals.
Railing between scale-car track and entrance to stock house.
Passageway from beneath chutes and outside of tracks.
Warning sign placed at empty bins about to be filled.
Knuckle guards on barrow handles.
Arrestor rail about skip pit to prevent hand barrows from falling into pit.
Steps or ladder to bottom of skip pit.
Clearance about skip car at sides and bottom of pit.

HOIST-HOUSE AND SKIP-INCLINE SAFEGUARDS.

Locked doors at entrance.
Inclosing entire drum with removable wire-netting guards.
Railing about drum and motor or engine.
Holsting cable run through chute to roof opening.
Connecting rods and cranks guarded.
Gears and screws on overtravel devices guarded.
Overspeed and slack-cable devices on hoist motors.
Locks for throttles and switches of hoist engine and motors.
Standard guarded switch boards.
Skip track equipped with shield at point 7 to 10 feet from stock house and yard level to prevent men from putting hands on rail.
Skip track equipped with shield on underside from top of furnace.
Overtravel device at top of skip tracks.
Safety clamp on cages thrown on by spring.
Sides of cage inclosed with sheet iron or small-mesh woven wire.
Cover over top of cage.
Gates at both top and bottom landings automatically operated by travel of cage.
Providing top platform with safety catches that secure cage at top.
Platform at sheave wheels.

SAFEGUARDS IN CONNECTION WITH INDICATING DEVICES.

Signal to cast house or blower’s office to inform of furnace hanging.
Speaking tube or telephone to furnace top.
Locks for bell and skip operating levers.

SAFEGUARDS FOR FURNACE TOP.

Shanty for top fillers, located behind or at side of hoist, with window opening away from furnace.
Rail about hopper to catch barrows.
Railed platform at top of receiving hopper.
Guards about distributor mechanism.
Permanent steps or caged ladders to sheave-wheel and other platforms.
More than one means of approach to furnace top.
Means of plugging rod hole when working on top.
Stretcher to lower men from top where descent is difficult.
Telephone, speaking tube, or electric-gong signal from top to stock house or cast house.

Steam connection to gas seal over big bell.

79704°—17—Bull, 140——9
Platforms connecting explosion doors, bleeder valves, and outriggers.
Bolting or chaining a number of explosion doors to limit their opening, or placing shields in front of doors.
Use of bleeder valves or explosion valves that allow only fine ore and gas to escape.
Elimination of "bracket and plate" top construction.
Elimination of rodding of furnace from top.
House or shelter on top to protect men from slips.

**Furnace-Stack Safeguards.**

Railed platform about shell to facilitate use of sprays for hot spots.
Shells double and triple riveted and with butt straps and of thickness up to 1\(\frac{1}{4}\) inches.
Corrugated-iron or steel wearing plates in place of, or in front of, brickwork at stock line, eliminating repairs during blast.
Permanent railed platforms about stack to allow access to cooling plates.
Steps or caged ladders to stack platforms equipped with a warning device to be operated when steps or ladders are in use.
Railed platforms on bustle pipes.
Bosh bands 1\(\frac{1}{4}\) inches thick.
Bosh plates anchored in boxes.
Tuyère breast armored with 1-inch steel plate or cast-steel jacket.
Strong bridle posts, rods, and springs.
Auxiliary bridle rods.
Elimination of pivoted counterweighted eyesights.
Elimination of spray cooling of hearth jacket.
Elimination of ditch about hearth jacket.
Hearth jackets to extend 4\(\frac{1}{2}\) to 5 feet below iron notch.
Strong hearth jacket up to 6 inches thick, and strong bands up to 2 inches thick.
Adequate tying in of hearth-bottom brickwork.
Two cinder notches.
Water-deflecting shields over skimmer trough and cinder-notch runner hung from bustle pipe.

**Cast-House Safeguards.**

Railed sides and railed or grated casting holes.
Runways at exits of cast houses.
Steel plate \(\frac{3}{4}\) to 1 inch thick on roofs with steep slope.
Ventilator about stack.
Short runners and railings along runners.
Bridges over runners.
Shutters operated from a safe distance by cables, steam cylinders, or counterweights.
Shields at hand-operated shutters.
Footpieces on shutters.
Shields over or below skimmer to prevent coke and slag from blowing down into cast house.
Shields at punch out and monkey skimmer.
Raising of punch-out gate and splasher from safe distance by cables.
Long pipe for iron-chilling trough.
Electric drills for opening tapping holes.
Shields for use in drilling or driving bars at tapping holes.
Automatic mud guns.
Funnels on clay cylinder and shield on nose of hand-operated guns.
Steam exhaust turned up and away from rear of gun.
Automatic cinder-notch bots.
Adjustable shields for hand botting.
Checkered floor plates.
Auxiliary signal to blowing room.
Protection plate in front of snort-valve lever.
Relay system by which signal to blowing room sounds "buzzer" at skip and bell operator's station.
System of red and white electric-light signals by which the hanging and slipping of the furnace can be signaled from stock house to cast house, or reverse.
Signal to boiler house from cast house.
Signal to gas washer from cast house.
Warning whistle, lights, or signs for slips, operated from cast house.
Catch basin for iron in runners leading to ladles and granulating pit.
Oxygen burner for hard or ironed tapping holes.
Means of holding "welshman" when bar is backed from tapping pole, so that no one is exposed to burns from flying iron.
Means of holding bar being driven into tapping hole to keep men out of range of misdirected stroke of sledge.
Water-supply pipe for cinder-notch coolers extending one-third or one-half around furnace before rising to circle water-supply pipe.
Elimination of cooling plates or boxes about sides of tapping hole.
Steep slope of skimmer iron trough.
Goggles, masks, leggings, box-toe shoes, and safety or gauntlet gloves provided at cost.

Safeguards in Connection With Iron Disposal.

Heavy bottoms in iron ladles and ladles equipped with devices for keeping them upright on frames or cars. Automatic couplers and safety chains. Steel underframes between trucks.
Each dumping crane or winch equipped with cable attached to hook fitted with hand hold, instead of chain and common hook.
Pourer at pig machine protected from splashes.
Trough men furnished with masks or goggles, and shields placed at end of spout over mold, or shields behind which men may work.
Walks over strands and runners and between strands from front to back.
Automatic knockers at discharge end of mold.
Shields of wire mesh at end of chain, also along car track opposite chutes.
Railings along columns of pig machine, except at passageway, which should be covered with plate shield.
Steam valves for lime sprags placed out of path of molds.
Lime run into lime vats by spouts from mixing tanks.
Standard guards for engine or motor, guns, chains, and transmission equipment.
Quenching pits with heavy brick walls or steel-plate shields, behind which men work.
Iron chills or depressions in yard into which ladle cleanings are dumped, and shields behind which men can work.
Ladle pits in floor of ladle house, provided with coping walls.
Part of ladle house in which skulls or scrap is broken to be inclosed for protection of man dropping ball.
HAZARDS AT BLAST FURNACES AND ACCIDENT PREVENTION.

GUARDS FOR GAS-MAIN SYSTEM.

Elimination of counterweighted explosion doors on downcomer, dust catcher, and mains.

Inclosure for base of dust catcher.
Operating device for bell lever on dust catcher that permits dumping by man standing a safe distance away.

Clamp to hold dust-catcher bell lever tight in shut position.
 Provision of large (4-inch) sprinklers to wet dust thoroughly as it is dumped into car.

Steam inlet to dust catchers.
Water seals in conjunction with valve mechanism at gas main offtake from dust catcher to prevent explosions or asphyxia.

Bleeder device at dead end of gas main.

Downlegs from gas main brought low to prevent flying of dust.

Clamping of bells on downlegs, and cables to open bells from safe distance.

Manholes of adequate size.

Close spacing of manholes.

Railings and platforms along tops of gas mains, with permanent ladder approaches.

Water-seal valves at points where parts of the system are to be isolated, with clamps for the bells.

Frequent downlegs, V pockets, or washing facilities, requiring less frequent work inside mains.

Pressure gage, reading in inches of water, to indicate pressure of gas in mains.

SAFEGUARDS AT GAS WASHERS.

Steps to top and to cleaning doors, side sprays, or water inlets.

Water-seal and mechanical valves on the inlet side, and water-seal valves on the discharge side.

Adequate ventilation by fans or exhausters when men are cleaning inside.

Rotary washer outside of building.

Fans for ventilating scrubber or gas-cleaning buildings.

System for controlling from gas house gas sent to engines and stoves.

Signals to boiler and engine operators.

Means of stopping ignition of engine in emergency.

Hourly registration by operator of cleaning house or inspection by watchman to determine operator's safety.

Automatic signal to warn operator of low-gas pressure.

BOILER-HOUSE SAFEGUARDS.

Provision for securely stopping gas from leakage past valve through burner into boiler when shut off for cleaning.

Blafking or locking of boiler blow-off valves.

Gage-glass shields that can be rotated when the glass is being changed.

Inward-opening firing doors.

Escape pipes from pop safety valves.

Best wire-wound steam hose for blowing tubes.

Nonreturn valves on steam nozzle.

Gas mains placed outside boiler house.

Permanent railed platforms from boiler to boiler, and for water tender, or permanent ladders for use when gage glasses are changed.

Permanent platforms with ladder or other approach at frequently used valves.

Permanent platforms for tube blowers.
SAFEGUARDS FOR STOVES.

Platforms at cleaning doors provided with means of approach that obviates climbing over top of railings.
Steps to top provided with frequent landings, with danger sign at bottom.
Locks for gas burner, hot-blast valve, cold-blast valve, and chimney valve.
Provision for preventing leakage of gas from burner into stove.
Means of turning gas into stove without man standing too close to door.
Blow-off valve muffled or provided with a 16-foot vertical extension pipe.
Hot-blast valve counterweights guarded.
Permanent platforms at hot-blast valve seat and valve chamber head.

BLAST-MAIN SAFEGUARDS.

Platform at gas-relief valve on hot-blast main. Ventilator over valve if inside cast house.
Check valve in mixer pipe.
Butterfly valve in cold-blast main on furnace side of snort valve.
Oil drain from cold-blast line at stoves.
Two spring-loaded blast-relief valves on cold-blast line, adjusted to blow off at any desired pressure.
Steam connection to cold-blast line at engine room.
Oil drain from cold-blast line at engine room.
Means of opening snort valve from outside of cast house.
Muffler on snort valve.

ENGINE-ROOM SAFEGUARDS.

A whistle of distinct and different sound for each furnace blown from the same room, and a number corresponding to the furnace displayed simultaneously with the sounding of the whistle.
Device to prevent engines from turning over backward owing to pressure of blast.
Guarding of fly-ball governors, rocker arms, connecting and tail rods, cranks, and air-inlet valves.
Guarding of flywheels with 5-foot wire fencing, carried over the bearings.
Three-rope drive of governor.
Emergency stop.
Relief valve at each end of air tub.
Automatic oiling system.
Checkered platforms, with standard railings and nonslip safety treads on the steps from gallery to gallery of engines.
Air intake from outside or guarded with wire netting.
Blocking for cylinder and flywheels.
Oxygen breathing apparatus at gas-engine rooms.
Forced ventilation of gas-engine basement.

SAFEGUARDS IN CONNECTION WITH SLAG DISPOSAL.

Valve for granulating-pit sprays placed at safe distance from runners and pits.
Tracks for cinder ladles covered at cast house.
Steam or air dumping of cinder ladle at dump. Devices on cinder ladles to prevent overturning in transit or loading.
Means of extinguishing burning clothing at cinder dump.
Cab on cinder crane so placed that it does not come over pit during travel of crane.
Prevention of steam from granulating pit from getting into cast house.
HAZARDS AT BLAST FURNACES AND ACCIDENT PREVENTION.

SAFEGUARDS FOR LADDERS.

Keeping portable ladders at storeroom, numbering them, and issuing them upon a return requisition.

Equipping portable ladders with metal spurs at the bottom and hooks at the top.

Keeping rungs of permanent ladder at least 8 inches from walls, columns, or stacks.

Providing cages for all permanent ladders more than 18 feet high.

SAFEGUARDS FOR SCAFFOLDS.

Removal of every piece of loose lumber from about plant.

Selecting scaffold lumber as lumber is shipped into plant, testing it for strength, marking it, and setting it aside for scaffold use only.

Placing scaffold lumber in store yard where it can be taken out and used only by authorized carpenters.

SAFEGUARDS FOR RIGGING MATERIAL.

Chains, cable, rope, and slings given out only by tool man or boss rigger, who has tables of safe working loads.

Inspection of material by boss rigger or assistant every time it is returned.

Destruction of defective rigging material as soon as dangerous condition is ascertained.

Safety belts and lines, with wrought-iron snaps, buckles, and rings.

SAFEGUARDS FOR YARDS AND TRACKS.

Elimination or guarding of all holes and depressions, close clearances, dangerous corners and doorways, walks and paths beneath cranes, and eaves of roofs near ladles being transported, poured, or loaded.

SAFETY APPLIANCES.


Stretchers at various points along trestles and in stock house, cast house, boiler and blowing room, shops, ladle house, and around pig machine.

Resuscitation apparatus.

One or more half-hour oxygen breathing apparatus.

Regular drill in first-aid measures and use of breathing apparatus, stretchers, and bandages.

MISCELLANEOUS SAFEGUARDS.

Handles on crane hooks.

Wearing goggles or masks in handling slag and metal.

Box-toe shoes for men handling material.

Portable railings for manholes and trapdoors.

Portable runways, cleated, and 24 inches wide, in place of miscellaneous plank.

Metal covers on all ditches and sewers, especially hot-water sewers.

Portable danger signs for use when any work presents danger to men in the vicinity, or for temporarily hazardous furnace or other conditions.

The foregoing list comprises only a small part of the guards used at blast furnaces. Those mentioned are considered desirable by one or more organizations. In addition to these, the market is full of guards of all kinds for protecting all sorts of places and for all the
A. SAFETY ENTRANCE TO BLAST-FURNACE PLANT.

The subway extends under all tracks inside yard.

B. WORKMAN IN DANGEROUS POSITION ON CAR. IS LIABLE TO BE STRUCK BY MAGNET.
A. LOCOMOTIVE CRANE, SHOWING GUARDS.

A, Rotating frame; B, swinging angle-iron bumper; C, floor plates; D, shield; E, hand iron; F, step; G, load indicator; H, extension for automatic coupler; J, coupler lever; K, warning sign.

B. GUARDS OVER FRICTION PULLEYS AND GEARS ON ORE POCKETS.

Note safety lines for stopping machinery.
machinery in the plant. Money may be spent without limit, every recommendation may be followed, and every appliance purchased, but if the installation of these appliances is not accompanied by a realization on the part of the force that they must be used, their full efficiency is not realized. Few guards or safety appliances can be made foolproof. To insure not only the maximum mechanical results from the safeguard but also the full benefit of the investment in the way of decreased accidents, the installation of safeguards has to be made the basis of further time and effort in educating foremen and men to think about personal responsibility and personal safety, in emphasizing the close relation of doing work efficiently to doing it safely, in continuing efforts to prevent hazardous work being done carelessly or routine work being done thoughtlessly, and in encouraging the cooperation of the men in correcting incorrect or dangerous practices, improving hazardous conditions, and suggesting plant betterments. The safety committee of workmen is generally accepted as being the best means of accomplishing the desired results.

Below is shown a warning sign used by one large blast furnace. The sign is made of blue and white enamel and gives general instructions to be observed around the blast furnaces, as well as mentioning special precautions to be taken when working on apparatus controlled by steam.

NOTICE
TO
BLAST-FURNACE EMPLOYEES.

Do Not Go up Stairways to Stove Platform or Furnace Tops Without Permission from the Blower.

Never Go onto Furnace Tops Alone.

Do Not Go Above the Receiving Hopper of Any Furnace Without Locking and Tagging the Levers Operating the Bells.

Do Not Go on the Skip-Car Tracks, in the Skip Pits, or any Place Where the Skip Car Can Hit You Without Locking and Tagging the Main Circuit Breaker on the Hoisting Engine.

Do Not Work on the Coke-Bin Door Cylinders Without Locking and Tagging the Levers Operating Them.

Do Not Enter Any Stove nor Clean Stoves from the Upper Platform Without Locking and Tagging the Cold-Blast Valve, Hot-Blast Valve, Chimney Valve, and Gas Valve.

Do Not Go Near the Gas Door of a Stove when on Gas.

Do Not Tighten Nuts on a Stove Door when the Stove is on Blast.

Do Not Use Telephone when a Misunderstanding Can Cause an Accident.

February 1, 1913.

BLANK COMPANY.
Plate XII, A, shows a safety entrance to the blast furnace provided at one plant. The subway extends under all of the tracks inside the yard.

Plate XII, B, shows the need of care on the part of men climbing in and out of cars, in order to avoid being struck by magnets, loads, etc. The man is shown to be in imminent danger of being struck by a crane.

An effectively guarded locomotive crane is shown in Plate XIII, A. The rotating frame A has been elevated to give a clearance of 8 or 9 inches over the deck of the truck. The swinging angle-iron bumper B serves as a warning by striking any one standing or leaning on the truck. The floor plates C are extended to the full width of the truck. The gears, clutches, and engines are guarded by the shields D. Grab irons E and steps F are suitably placed for the safety of men getting on or off the crane. An automatic load indicator is shown at G. At H are shown structural extensions to both ends of the frame, to which automatic car couplers are attached, allowing the crane to be coupled to cars without danger. A coupler-operating lever, J, and a warning sign, K, are also shown.

Plate XIII, B, shows guards over friction pulleys and gears on blast-furnace ore pockets. Safety lines with handles to be pulled to stop machinery are also shown. The rope pulls out a switch and, cutting off all power, sets a brake, stopping the machinery.

A thoroughly guarded platform and stairway leading from the cab of a skull-cracker crane to the crane bridge is shown in Plate XIV, A.

Plate XIV, B, shows blast-furnace boiler counterweighted doors which open inward and upward, eliminating danger from any fire-box explosion.

Plate XV, A, shows a high-tension junction pole, equipped with ladder and with platform at the top and guard plates on the sides of the ladder to protect a man while passing up through the wires.

Plate XV, B, shows a heavy wire mesh guard at the oil switch and a lightning arrester in a blast-furnace power house where the electric current is 6,600 volts.

A well-guarded Bessemer mixer crane is shown in Plate XVI, A. A safety limit switch, A, prevents overtravel of the hoist. The carbon contacts, B, are brought together when the hook block raises the hinged arm of the switch. When the contact is made the armature is short-circuited, stopping the motor. A safety grease cup, C, and a shield, D, over the sheaves are shown.

Plate XVI, B, shows boxes used at one large blast-furnace plant to contain woolen blankets for use in case of fire to employees' clothing. The round box is a portable moisture-proof can used where naphtha oil is applied to pipe, rails, or other material with portable
A. PLATFORM AND LADDER WITH GUARD PLATES, ON HIGH-TENSION JUNCTION POLE.

B. WIRE-MESH GUARD AT OIL SWITCH, AND LIGHTNING ARRESTER USED AT BLAST-FURNACE POWER HOUSE.
A. GUARDED PLATFORM AND STAIRWAY FROM CRANE CAB TO BRIDGE.

B. COUNTERWEIGHTED DOORS ON BLAST-FURNACE BOILER; DOORS OPEN INWARD AND UPWARD.
spray pumps. Boxes like the square one shown are permanently located at numerous places throughout the plant where there is danger of the clothing catching on fire. The door of the box automatically locks from the inside, making it necessary to break the glass to remove the blanket. The broken glass falls through a slot in the bottom of the box. The hook shown is for use in breaking the glass.

Plate VIII, B, and Plate VIII, C, show a safety hook for use where hoisting is done in a confined space, with consequent danger that the hoisting bucket may catch on walls and become disengaged. This hook is used by bricklayers on stacks, blast-furnace stoves, etc., and by boilermakers, machinists, and others. Plate VIII, B, shows the hook closed. The sleeve A fits into the notch B and locks the hook, making it impossible for the bucket to become disengaged from the hook and fall on workmen, either when the bucket is being hoisted with a load or lowered when empty. Plate VIII, C, shows the hook open. The latch C drops and is locked automatically.

An efficient type of car'sifter is shown in Plate XI, C. A four-cornered piece of hardened steel is inserted in the forging. When one corner of the steel becomes worn the steel is driven out, turned around, and another corner is used.

MEANS OF ACCIDENT PREVENTION.

RELATIVE VALUES OF DIFFERENT MEASURES.

Few attempts have been made to valuate various methods of accident prevention, but one company has expressed the relative values of methods of preventive measures as follows:

Relative values of accident-prevention measures.

<table>
<thead>
<tr>
<th>Preventive measure</th>
<th>Value, per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td></td>
</tr>
<tr>
<td>Attitude of officers</td>
<td>20</td>
</tr>
<tr>
<td>Safety committees</td>
<td>20</td>
</tr>
<tr>
<td>Inspection by workmen</td>
<td>5</td>
</tr>
</tbody>
</table>

| Education:                          |                  |
| Instruction of men                  | 15               |
| Prizes                              | 9                |
| Signs                               | 3                |
| Lectures                            |                  |
|                                     | 30               |

| Safeguarding:                       |                  |
| Safety devices                      | 17               |
| Cleanliness                         | 5                |
| Lighting                            |                  |
|                                     | 25               |
These figures are representative of many years' experience, but further experience will undoubtedly lead to further changes. In fact, experience with financial rewards to foremen and men for results in accident reduction indicates that "prizes" should receive a much higher valuation than is assigned. Comparative accident reduction over two years in which a bonus was paid individual employees for accident prevention shows comparative rates of 100, 54.9, and 24.6.

PLANS FOR PAYING BONUSES.

The bonus for a foreman is paid in a variety of ways. One scheme is to fix the bonus at a certain sum per man on the foreman's gang. At $2 per man of a 20-man gang the maximum payment would be $40 if no accidents occurred. To fix a "bogey" rate, the accident rate for the preceding one, two, or three years may be taken. Assuming a rate fixed at 20 per cent to start, and that at the end of the period it has been reduced to 12 per cent, the bonus will be twelve-twentieths of $40, or $24. The period at the end of which the award is made may vary from six months to a year. Reductions of accidents of 45 to 70 per cent have been effected by bonus payments.

Another scheme of bonus awarding is as follows: A plant is divided into districts and a committee in each is appointed to serve for a period of two months. A datum line showing the frequency of prior accidents in each district, in units per 100 men employed, is established. Each district is expected to equal or excel its previous record, the records not being set against each other, but the record of each being wholly within itself. Each 60-day record is merged into the previous total, and a new record is automatically set. For each man of a committee that equals or excels its own record during a 60-day turn there is provided a $10 prize. In addition, the committee making the greatest improvement is granted a double prize, or $20 to each man. This plan of cash reward for accident prevention reduced accidents by approximately 60 per cent in one year.

The obvious objection to these plans is that as accidents decrease there will be diminishing returns to the foremen or committeemen. To offset this situation the basing rate should be increased by 10 to 40 per cent at the commencement of each period.

INSTRUCTION OF MEN AND LECTURES.

If "instruction of men" and "lectures" be grouped as preventive means the rating is 18 points. "Lectures" refers to a policy of having a foreman get his men together and give them a brief talk on the importance of safe practices, giving emphasis to the policy of the management, and mentioning specific instances of injuries and the means by which they are to be avoided. This practice is one way of recognizing that the foreman is the main factor in determining the
A. CRANE HOIST, SHOWING SAFEGUARDS.

R. Safety limit switch; B, carbon contacts brought together when hook block raises arm of switch, short-circuiting motor; C, safety grease cup; D, shield over sheaves.

B. CONTAINERS FOR WOOLEN BLANKETS FOR EXTINGUISHING BURNING CLOTHING.

Can is portable. Box is placed at danger point; has automatic inside lock, glass front, and hook for breaking glass; cross is green enamel.
quality and quantity of work done by the men under him. After a plant has been constructed according to the best design and has been provided with adequate equipment, the output, the upkeep of the machinery, and the efficiency of the men, including their freedom from injuries, depend on the foreman. Perhaps the most difficult problem in accident prevention is to arouse among the foremen a genuine interest in efforts to avoid accidents. Often certain risks are realized but are regarded as necessarily incident to the work. This does not mean that foremen are indifferent to the safety of their men, but that their first concern is production. If they realize that accident prevention decreases the cost of production and does not conflict with the work, but that it should on the contrary increase the efficiency of the men as many accidents are due to inefficient methods of work, they do not lack interest. Given this interest, instruction of their men by talks, admonitions when the men are seen taking uncalled-for risks or hazards, and adequate supervision follow automatically.

Other “lectures” are motion pictures pertinent to plant safety, stereoptican lectures, and conferences. At some plants the management hires a large hall for a meeting place, provides cigars and light refreshments, invites all the men the hall will contain, and asks a free discussion of methods, advantages, and results of safety work. When a bonus scheme is in effect a public meeting is made an occasion on which to present prizes.

SIGNS, CLEANLINESS, AND LIGHTING.

Signs, cleanliness, and lighting are given a rating of 3, 5, and 3 per cent, or a total of 13 per cent. These features, if defective, can be corrected almost immediately. The use of signs calls for considerable discretion. In plants giving much attention to safeguarding, it has been found that when signs are used too lavishly employees become so familiar with such warnings that the desired purpose is defeated. About blast furnaces permanent signs may be used at the following places without fear of overplacarding the plant:

1. Steps to top of furnace and stoves.
2. Steps to gas-engine basements and to tops of boilers.
3. Beneath pig-machine strands or chains.
4. At railroad crossings and track approaches.
5. At electric conductors carrying more than 250 volts.
6. At close clearances along tracks.
7. Under dust catchers.
8. About skull cracker.

It is the consensus of opinion that the English word “danger” in white on a red sign carries to the foreigner who understands no English exactly the same significance as to English-speaking people,
because he can readily understand that it is used only to indicate places of peril. Such permanent signs should be lighted at night. Small signs that can be attached to electric switches, and to water, steam, vacuum, blow-off, or gas valves should also be provided. These should have a white "danger" on a red background. Portable signs to be placed under men working above, or where men are chipping, cutting rivets, or breaking scrap in the cast house or the ladle house, or shooting salamanders or frozen ore, should be provided.

Cleanliness is characteristic of most blast-furnace plants, and emphasis on this point would be largely misplaced. Furnace work being a rough trade and productive of much rubbish, brickbats, slag, and scrap lumber and iron, it is necessary to keep everlastingly at the work of cleaning up, and as a rule, yards, cast houses, pavements, and houses are worthily neat. The few exceptions only go to prove the rule.

ACCIDENTS AND ACCIDENT PREVENTION AS RELATED TO THE EMPLOYEE.

LOSS OF TIME.

Anyone who has worked with or has had the direction of workmen realizes that one of their chief fears is that they will lose time and wages as the result of time keeping or other clerical errors, plant shutdown, or enforced absence. With average full-time weekly earnings of $12.43 for laborers to $19.13 for keepers in the furnace industry, an average loss for injury of $17.95 over noncompensated periods, or $50.24 over average compensated periods, represents an impairment of income that is sometimes accompanied with hardships and deprivations. It is common to see painfully injured men bearing their injuries stoically and bravely but seemingly undergoing much mental suffering on account of the uncertain loss of time and income facing them.

Malingering is an act of which men are sometimes accused. On the other hand, many injuries terminate long after the normal period, owing to lack of proper medical care caused by unsystematic follow-up arrangements, neglect on the part of the man himself, or a lack of system in returning the injured man to work when the condition of the injury is such that the probability of additional loss is exceedingly remote. The average duration of all injuries is 17 days. A large steel works having an excellent follow-up system and medical treatment reports 12 days as an average of all injuries when more than a day's lost time is necessary. Infections ordinarily comprise 1 in 39 injuries, but with adequate medical treatment they are reduced to 1 in 900.
The 14 days' exemption period provided by law is designed to prevent malingering and to put upon the employee a sufficient part of the burden of accident cost so that he has a strong incentive for returning to work promptly. This provision of law is essentially a safeguard provided for the employer against unjust claims. It is based on the probable malingering of a minority of employees, and it works a real hardship on the majority. Under these circumstances one of the best means of demonstrating the usefulness of accident-prevention means is for plant managements to undertake measures that will return men to work at the earliest possible hour.

When employees realize that every practicable attention is being given to this phase they will tend to accept without reservation the intention of the management to undertake safety work for the good of the employee as well as that of the employer. There is not infrequently resentment against lost time imposed by the physicians' order. Until any possible grounds for such resentment are removed, it is almost useless to talk safety to men on the basis of loss of time. With satisfactory conditions, loss of time is a strong point in impressing on employees the importance of personal care.

**DISCIPLINE.**

Imposition of discipline or fines for infraction of a safety rule or for carelessness is a cause of resentment among employees. Intelligent carelessness all the time is beyond the power of most men, of any station, especially among a large proportion of furnace employees. Discipline for trivial offenses, for mishaps as a result of desultory and untrained methods of work, or as aggravated by personal antipathy of a foreman for a workman injures the cause of safety among the men more than it can possibly help. So far as is known, fines have been imposed at only one plant. Layoffs or discharges are in the hands of the foremen and the superintendent at most plants, the suggestion or recommendation of the safety inspector being mandatory at only a few plants. Two plants settle the question of discipline by a "court of inquiry," where all concerned in an accident and all witnesses are invited to give their version or make defense. Thus the man is judged to his own satisfaction by his associates. Wherever foremen of gangs will surrender their prerogative of discipline for infractions of safety rules, the court mentioned removes another obstacle in safety work.

**USE OF INTOXICANTS.**

In few of the accidents reviewed was drunkenness given as the primary or contributing cause of injury. This is probably due to two facts: First, drunken men are without exception turned back from
all plant entrances; and, second, men coming to work after alcoholic excess are, though not intoxicated, either sleepy and dull, ill, or reckless. Although a man in such condition has neither mental or physical balance, and is more susceptible to accident; in event of accident the part played by alcoholism is determined only as result of time and effort in tracing back a suspicion to a certainty, an effort comparatively seldom made.

In the eradication of personal habits or excesses detrimental to the safety of the men, alcoholism must at times be given attention, but the matter is to be approached with caution, welfare effort in this direction being often resented as an encroachment on personal liberty. The fairness of such work can be impressed upon men by making clear that the compensation act means the discharge of a man who gets hurt too frequently, because he is a bad risk to the company, that such a man eventually will not be able to keep himself in a job, and that alcohol in excess will surely bring any man to such a state. Fortunately, alcoholism has not been an extremely serious factor in accident-prevention work at most furnace plants, because an habitual, excessive drinker soon loses his job about a furnace through too frequent absence or too frequent intoxication.

ATTITUDE OF FOREMEN.

The attitude of foremen, subforemen, and “straw bosses” toward safety work determines largely how the men view the work. Some foremen think that a man who is clearly careful must be too careful, that he does not do as much work, or does not do the set work as quickly as other less careful men. As the foreman is in contact with the men, and sets the policy for the manner in which work is done, the success of efforts to interest the men rests largely with him. Nothing can so effectively smother safety-committee work, men’s suggestions, bulletin-board publicity, or stimulation by prizes, as a foreman’s conflict with suggested safeguards or changes in methods of work. The management of plants should make it evident that the safety of the men in each foreman’s gang is of at least equal importance to the efficiency or productiveness of the gang by the way in which the foreman is paid or promoted. Foremen can use the same incentives to induce carefulness that they use to induce efficiency. It follows that workmen will promptly assume their share of the work and responsibility.

PHYSICAL EXAMINATION.

The physical examination of workmen as a means to promote industrial safety is much used in large plants. It has met with opposition from workmen who fear the information derived from the
examination will be used to their disadvantage. Physical examination should be made with a view to fitting a man's work to his mental and physical capacity, not to weed out defectives from the employees unless the defect results from a clear-cut case of bad personal habits.

Physical examination of workmen has probably resulted in more good than in hardship to workmen, particularly those who are uneducated in American schools. The tendency of these men is to neglect physical weakness until they become permanently impaired. If as a result of physical examination men afflicted with unsound hearts, hernia, or deafness are given work less hazardous to themselves and to others, or if the examination discloses incipient tuberculosis, defective sight, varicose veins, or infectious social diseases, with the result that the defects are cured, the examination should not meet with objections from any except the small percentage who object on the ground of paternalism or have religious or personal reasons for declining examination. Physical examinations conducted in the right spirit and at proper intervals will bring greater health and safety to workmen.

**RELATIVE HARDSHIP.**

It goes without saying that safety work is of advantage to both employer and employee. Yet, in seriousness of burden, caused by unsafe conditions, the employer escapes lightly. With an accident rate of 500 per 1,000 men, the estimated cost would be only $0.028 per ton of pig iron. The employee, on the other hand, stands one chance in two of partial impairment of earning power, amounting, on the average, to 2 to 3 per cent of his yearly income, not to mention his liability to loss in earning power of thousands of dollars by permanent disability. So it is true that accident-prevention work on the part of the employer must rest on more than a desire for a good showing on the profit side of the ledger.

Another important inducement for the employer to provide the maximum of safety is embraced in the general labor situation. The mass of labor about blast-furnace plants, except in one district, has been composed of immigrants, and the standard or level of wages has been the lowest of any department of the steel industry.

It is a matter of record that Americans born of native or foreign parents are not attracted in large numbers to the industry. It is a live question as to whether it will be possible to continue to attract the immigrants, or whether with future changes of conditions in their native lands men will not cease to emigrate. It is more than likely that a future problem of the furnace industry will be to attract immigrants, or to attract American-born laborers, by making employment more inviting. The problem will be partly technical,
involving the character of work to be required, and partly socio-
logical, involving the conditions under which the work is performed. Development of safety measures, such as improvement of working conditions, that is, providing adequate sanitation, locker, bathing, and lunch rooms, and drinking-water facilities; encouraging better home life, conserving health; eliminating so far as possible fatigue and occupational diseases, and lessening the causes of dusts, gases, vapors, and fumes, excessive heat and cold, glaring lights will go far to supplement the work set for technical men in lightening and making more attractive the work performed about furnace plants. Thousands of dollars have been spent in this work, and the tendency to make improvements is constantly growing. The record of many plants in this respect is one of progress and recognition of their responsibilities, and there has been almost more betterment in conditions of employment in the past 5 years than in the preceding 50.

Safety work, therefore, should rest on a very secure conviction in the minds of both employers and employees that it is a decided necessity.

SAFETY-COMMITTEE WORK.

IMPORTANCE OF SAFETY COMMITTEE.

Throughout this report repeated mention has been made of the necessity of persistent and continued personal efforts on the part of foremen to correct careless and unskillful methods of work. The writer's observations lead him to believe that herein lies the best hope of reducing the large number of accidents that no safeguarding can eliminate. To anyone who has studied the types of accidents cited a similar thought must have occurred. In concluding the report with a discussion of some aspects of safety-committee work, emphasis is again laid on the importance of daily personal work by foremen to supplement the efforts of safety committees.

The methods of organizing safety-committee work are known to all officials of furnace establishments and need not be gone into here. At the time this report was prepared all blast-furnace plants operated in conjunction with steel plants were utilizing safety committees of men, or of foremen and men, as an aid in reducing the number of accidents, and the work of the committees was meeting with success. However, few isolated plants had found the safety committee to be an unqualified success.

SAFETY COMMITTEE AT A SMALL PLANT.

A small plant is under a handicap in undertaking safety-committee work. For one reason there are fewer accidents in a force of 100 men than in one of 400, so that the safety committee at the larger
SAFETY-COMMITTEE WORK.

plant has a bigger task and one that engages its respect and interest at the start. There is always some practice, condition, or equipment that has caused a more or less severe accident. This they can talk about and correct with some satisfaction to themselves. At the expiration of their service their endeavors are represented by a respectable amount of work accomplished. The committee may have an average of five to seven accidents to engage its attention during one month. These accidents give the committee something definite to do; there is something concrete to correct; unskillful, thoughtless, or incorrect practices and hazardous conditions can be pointed out. The committee at the small plant, with exactly the same rate of accidents as at the large plant, will have to consider an average of only one or two accidents per month. Even with the utmost stress, the safety committee at the small plant can not make the significance of one or two accidents as striking to the individual man they are trying to reach as if five to seven had happened.

Experience shows that the average committee at a small plant expends its efforts mainly in providing mechanical safeguards, which is the logical line of endeavor at the inception of a safety campaign. However, the tendency is to persist in this field, which gradually narrows, so that the committee, finding its efforts to accomplish useful safeguarding becoming circumscribed, sooner or later begins to consider its work futile and loses interest long before the actual hazards of the plant, as indicated by the accident rate, have been reduced to the lowest possible figure and kept there. The work loses momentum while improvements are still needed in methods of work, scaffold practice, condition of tools, upkeep of rigging, and other details, and while the workmen only partly realize the full significance of accident-prevention efforts.

To make safety-committee work at a small plant permanent and of everyday usefulness, experience at a few small plants where it has been a success indicates that the committee has to be given a larger field than that assigned to committees at large plants where the work supplements the safety work of the whole steel plant.

One successful plan is to make the safety committee an efficiency committee, putting up to the committee of foremen the question of plant economies. Every two weeks the committee has a meeting, at which minutes are kept. The superintendent meets with the committee as often as he has any improvements, readjustment of force, or similar matter in mind and talks it over with the foremen. When an unusual job is to be undertaken, it is discussed from beginning to end, and all possible contingencies are brought out by the men from the various gangs or departments, and after the best way to handle the work is apparent the sense of the meeting is expressed.

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in a "work order," which gives explicit directions as to how the work is to be done, who is to direct it, and the precautions to be taken. Economies in storeroom supplies, the handling of material, the labor problems, and similar matters are discussed. The foremen constituting such a committee come to realize the value of cooperative effort, and in connection with the committee work the men advance valuable ideas. The plan is not such a radical departure from accepted plant organization, as every superintendent discusses personally with his foremen all unusual developments in the foreman's work. Referring such matters to the plant committee simply applies to a small plant the idea of a general conference, largely used in big organizations.

**OUTLINE OF FOLLOW-UP WORK.**

To insure a permanent and active plant committee the superintendent may outline for the committee a broad field of accident-prevention activities. The provision of safeguards can be largely left to the initiative of the committee, with occasional suggestions as the need for them comes up from time to time. However, guidance may be needed in outlining a follow-up system of correcting unsafe conditions and practices. The typical outline given below may be useful. For putting such follow-up systems into practice a form should be prepared, to be signed at each plant inspection by the committee men. They should be given authority to correct or to ask foremen to correct any dangerous condition or practice that is not in conformity with logical requirements for safety.

*Outline of follow-up work by safety committee.*

[List of items to be observed in promoting general safety about blast-furnace plant.]

**TRESTLE.**

1. Condition of walks, railings, and crossovers.
2. Condition of tools and manner of using tools.
3. Loose material or tools along walks.
4. Use of safety belts in cars and bins.
5. Carefulness of larry-car, ore-bridge, and train operators.

**STOCK HOUSE.**

1. Condition of fenders, lights, and gongs on scale cars.
2. Condition of bin chutes, freedom from lumps liable to fall, and practice in drawing material.
3. Condition of barrows, tools, and lights.
4. Use of goggles and carefulness in breaking lumps, drawing dusty coke, and running scale car.

**HOIST.**

1. Replacement of guards on hoist, engine, and motor.
2. Use of locks or tags on operating levers and switches.
3. Safety of work in cleaning skip pit and in oiling hoist, skip, and engine or motor.
4. Observation of rules for oiling and inspecting on top.

CAST HOUSE.

1. Condition of railings, steps, and floors.
2. Filling of ladles (not more than within 6 inches of the top).
3. Putting water on trough after cast.
4. Use of shields at tapping hole, cinder notch, and shutters.
5. Use of goggles and masks at cast or flush.
6. Filling of cinder ladles (dryness of ladles and not more than within 6 inches of the top).
7. Condition of tools (no mushroomed heads, cracked handles, or loose sledge).
8. Cleanliness of cast-house floor, and replacement of tools in proper position.
10. Tight bridle springs.
11. Condition of shoes and clothing of cast-house crew.

STOVES.

1. Locking or tagging of gas burners and hot-blast valve when men are inside cleaning stove.
2. Leaky gas burners.
3. Men standing about in front of stove doors.
4. Handling of gas in lighting and in cleaning wells.

BOILERS.

1. Locking or tagging of burners and blow-off valves when boilers are being cleaned.
2. Water-gage glass protection and manner of using glass.
3. Condition of steam hose.
5. Men working alone above boiler settings.
7. Lighting.

GAS MAINS.

1. Proper handling and wetting down of flue dust.
2. Nonuse of clamps on bells and downlegs.
3. Condition of water and steam lines to gas mains and to water-seal valves.

ENGINE ROOM.

1. Accompany oilers and wipers to observe whether there are hazardous conditions and practices.
2. Inspect platforms and steps for excess oil and slippery conditions.
3. Inspect railings.
5. Condition of oxygen apparatus.

PIG MACHINE AND LADLE HOUSE.

1. Condition of shoes and clothing of men.
2. Length of poles used.
3. Use of goggles.
4. Method of work at quenching pit.
5. Condition of tools.  
6. Absence of rubbish under foot.  

**Transportation.**  
1. Unauthorized persons on railroad equipment.  
2. Use of danger sign by men working in, under, or about cars.  
3. Kicking of cars across drives, roads, passageways, or into dead-end tracks.  
4. Proper use of bell and whistle.  

**Yards and General Labor.**  
1. Piling of brick, lumber, castings, and pig iron.  
2. Use of ordinary plank for runways.  
3. Safety of work at cinder dump.  
4. Yard cleanliness.  
5. Guarding of holes, ditches, etc.  

**Cranes, Hoists, and Rigging.**  
1. Method of work in booking on.  
2. Methods of work in cars with buckets and magnets.  
3. Leaving balls of buckets standing up.  
4. Use of proper slings for hoisting material.  
5. Inspection of block and tackle—frequency of inspection, care while being stored, disposition of defective material.  
6. Condition of tool-room tools and supplies.  

**Ladders and Scaffolds.**  
1. Selection and suitability of scaffold material.  
2. Condition of existing scaffolds.  
3. Scaffolds constructed by men other than carpenters.  
4. Eliminate miscellaneous makeshift ladders and scaffolds.  
5. Condition of permanent and portable ladders.  

**General.**  
1. Condition of previously installed safeguards.  
2. Condition of electric-light and motor-extension cord and cable.  
3. Condition and legibility of danger signs.  
4. Use of portable danger signs.  
5. Condition of stretchers.  
6. Condition of and training in resuscitation and breathing apparatus.  

[To the above may be added the outstanding causes of accident as shown on pages 10-11.]  

**NEED OF REPORTING MINOR INJURIES.**  

The men comprising the safety committee should make special effort to get every man suffering injury to report to the first-aid room for treatment. Any injury, however slight, should be reported, including every bruise, cut, scratch, abrasion, strain, foreign body in the eye, or blister. If all such injuries are reported, in the average small plant 10 to 20 injuries will be treated each month. In some large plants where practically every injury is reported, 10 to 15 per
cent of the force report at the hospital every month for treatment. Most of the injuries are trivial, but many of them might become serious through infection if neglected. The safety committee of a small plant can do much effective work in helping its own plant to reach the same record in the reporting of trivial injuries. In so doing, not only will the number of infections become markedly lessened and men be saved considerable lost time, but the safety committee will at the same time place itself in an increasingly stronger position to emphasize the importance of its work by the number of accidents to which it can refer.
GLOSSARY.

AIR TURB. The cylinder on blowing engine which pumps the blast, "wind," or "air."

BARRELING SCRAP. Prying adhering scrap from runners, ladles, or skimmers.

BIN FEEDER. Man who rods or bars ore that sticks in going through bin doors.

BIN MAN. One who pokes down ore in bins to keep it moving to the chutes.

BLEEDER. An escape valve for gas, at the top of the furnace or along the gas line, to relieve excess pressure.

BLOWER. Foreman in charge of operation of furnace and stoves, casting, flushing, stops, repairs, etc. At small plants he is in charge of trestle, stock house, and plg machine as well.

BLOWING ON THE MONKEY. Flame blowing from the cinder notch.

BOIL. Occurs when molten iron runs over a wet or damp spot or object in runner. The sudden generation of steam often causes an explosion, whereby molten iron is scattered about.

BOILER SCALER. Man who cleans scales from boiler tubing.

BOT. A cast-iron or forged-steel plug mounted on long steel rod that fits inside of the monkey.

BOTTING. Thrusting bot into monkey to stop run of slag during a flush, or when the furnace begins to blow on the monkey.

BOTTOM FILLER. Man who fills barrow with ore, coke, or stone, weighs it and places it on cage, or elevator, to be hoisted to top of furnace.

BURNER, BURNER MAN. A man who takes care of kilns for roasting ore; largely confined to plants roasting sulphur from Cornwall, Pa., ores.

CAGER. Supervises weighing and sequence of sending up components of furnace charge, keeps track of number of rounds, and signals to top filler when it is time to hoist.

CAR DUMPER. Mechanical device for tilting a railroad car, hopper, or gondola over sideways to empty it.

CAR RIDER. Brakeman or laborer employed to ride on car being hauled up to dumper, or on car pushed from cradle, to apply brake and prevent hard bumping.

CAST HOUSE. The roofed (and sometimes inclosed) space in front of and about a blast furnace in which molten iron is run or cast.

CHECKER ARCHES. Fire-brick supports built up of arch brick or keys to support the checkerwork on the second, third, or fourth pass of hot-blast stoves.

CINDER BANK. Same as cinder dump; indicates an old dump as distinguished from one in use.

CINDER BREAKOUT. The slag within the furnace penetrates the brickwork and escapes.

CINDER DOCK. A bed containing molds into which, in former practice, slag was run, chilled, and then thrown into cars with forks.

CINDER DUMP. Place where slag ladles are emptied.

CINDER FALL. See Cinder runner.

CINDER NOTCH. The hole, about 5 or 6 feet above iron notch, and 3 feet below tuyères through which slag is flushed two to three times between casts.

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CINDER PIT. Large pit filled with water into which molten slag is run and granulated.

CINDER RUNNER. Trough carrying slag from skimmer, or cinder notch, to pit or ladle. Also called cinder fall.

CINDER SNAPPER. Man who removes cinder skulls from cinder runners between cinder notch or skimmer and pit ladles.

CLAY GUN. See Mud gun.

CLEAN-UP MAN. Usually a pensioner who keeps yard cleaned up, pulls weeds, and does odd jobs.

CONDUCTOR. The third rail or electric wire on car dumpers, ore bridge, transfer or larry car. Also conductor on hot metal or roustabout engine.

COOLER ARCH. An opening in the tuyère breast of the furnace. The tuyère cooler is placed in it.

CRAB. Temporary hoisting winch or permanent winch used to pull ladles, cars, or iron plate in boiler shop, also called "mule" on car dumper.

CRADLE. Part of car dumper in which the car rests when it is dumped.

DRILLING UP. Preliminary digging out the clay in the tapping hole. This is done with hand, air, or electric drill.

DUST BELL. Seal at bottom of dust catcher, dust leg, or water-seal valve; is opened periodically to drain flue dust from the system.

FURNACE HOLDING-THE-IRON. Furnace gives much less than normal quantity of iron at casting, although the feed may have been regular. The tapping hole runs iron slowly, and the amount of slag is somewhat scanty. Compare "furnace losing-the-iron."

HANDYMAN. At small plants a "Jack of all trades," rigger, millwright, and machinist combined.

HOIST MAN. One in charge of running skip and dumping bells.

HOOK BLOCK. The lower sheave or block on a crane hoist to which a swivel hook is attached.

HOOKER-ON. Same as Hook-on.

HOOK-ON. Man who adjusts cables or chains about objects to be lifted or places hook of crane block in bucket balls, hooks of winches to objects to be moved, etc.

HOT-BLAST MAN. See Stove tender.

HOT SPOT. Any small portion of the furnace shell that is thin and seems likely to burn through.

IRON PILES. A laborer who removes iron from cars, sometimes breaks it, and piles and classifies it according to grade.

KEEPER. One in charge of opening and closing of tapping hole. Runs iron at cast.

KISH. Graphite that separates from pig iron in runners, ladles, molds, or mixers.

LADLE CHASER. A man who distributes hot metal in ladles to different operations, keeps hot-metal crew busy to prevent skulling of ladles and delay at mill.

LADLE-HOUSE MAN. See Ladle liner.

LADLE LINER. A man who lines, with brick, loam, and clay, ladle thimbles of hot-metal cars.

LADLE SKULLER. Laborer who removes rim and bottom skulls from hot-metal ladle cars.

LIME MAN. Attends to slaking lime, running lime water to vats beneath pig-machine mold, and operates lime sprays when machine is running.
HAZARDS AT BLAST FURNACES AND ACCIDENT PREVENTION.

LINEMAN. In charge of maintenance of light and power electric circuits, sometimes including switchboard; usually inspector takes charge at switchboard.

LOAM BOX. A container in which loam is boiled in water by means of a steam pipe. The mixture is used in blast-furnace runners.

MONKEY. Small water-cooled bronze casting in cinder-notch cooler through which slag runs from cinder notch when bot is withdrawn.

MONKEY BOSS. Man in charge of flushing furnace and of claying up monkey and coolers. Helps on tapping hole also and at cast.

MUD GUN. A steam cylinder operating a plunger inside a steel tube 6 inches in diameter. Clay is fed into hopper tube as plunger is worked back and forth and is thus forced into tapping hole, at end of cast.

MULLIGAN. A heavy double-hand sledge for breaking runner scrap.

NIGGERHEAD. A slip pulley on hoist winches. Rigger takes a few turns of the hoisting rope about the pulley and, by varying tension on the rope, can vary speed of hoist on lowering object with engine running or hoist running.

ORE BRIDGE. A large electric gantry type of crane, which, by means of clamshell bucket, stocks ore or carries it from stock pile to bins or larry car on trestle.

ORE-BRIDGE BUCKET. Clamshell grab bucket of 5 to 7½ tons capacity.

OREGON SLEDGE. A broad-faced sledge hammer.

PICKING ROD. PICKING ROD. (1) A 1½-inch steel rod, about 20 feet long, used to ram into the tapping hole, while furnace is casting, to dislodge obstructions preventing a good run; also called tapping bar. (2) A bar or rod used for cleaning tuyères and blowpipes.

PIG STICKER. Man who punches or knocks pig iron out of chills or molds at pig-casting machine.

QUENCHING PIT. A pit filled with water in which graphite, residue of iron, and slag from hot-metal ladles is granulated.

RAVELING. Pulling material out of ladle, furnace, or iron trough at tapping hole. Used in different sense at steel works.

RID-UP RUNNERS. Ridding up; cleaning up after a cast, when the scrap, slag, and iron are removed from runners, troughs, and skimmers, and they are freshly clayed, loamed, or sanded.

RIGGER. Semiskilled employee, duties concerned largely with construction and repair rather than maintenance. Skilled in use of hoist tackle, winches, etc., and usually able to do riveting and to assemble material.

SAILOR. A term sometimes employed for rigger, painter, or structural worker.

SCRAP PICKER. A man employed on slag dump to pick out lumps and sheets of iron carried to dump in slag ladles.

SCRAPMAN. See Scrapper. May also refer to man who breaks and removes heavy scrap in cast house.

SCRAPPER. One who removes scrap from bin, cast house, or chute to skip pit and charges the material removed into skip at regular intervals.

SINTERING MAN. One in charge of plant for sintering flue dust, or simply an employee there.

SKIMMER. Device on tapping-hole trough next furnace by which slag is automatically removed or skimmed from top of iron at cast and diverted to ladles or pit.

SKIP PIT. Hole into which skip descends when at bottom of skip incline in stock house, to bring its top below discharge chute of scale car.

SKULL. Solidified iron, graphite, and cinder in ladle. Solidified mass in front of tapping hole.

SKULL CRACKER. See Skull drop.
GLOSSARY.

SKULL DROP, SKULL CRACKER. Device for breaking heavy ladle skulls, iron from messes, or scrap.

SNORK VALVE. A butterfly valve opening from cold-blast main to atmosphere. Allows casting at the furnace without shutting down blowing engines. Operated by large wheel or lever in cast house.

SPELL. A rest period for crews at furnace, stock house, etc., or a period of work in drilling tapping hole.

SPLASHER. A plate lined with fire brick, which is placed over iron trough next to tapping hole to keep down flame that blows from tapping hole during a cast.

STOCK. Term applied to the mixture of ore, coke, and limestone charged into the furnace or stored in bins at stock house.

STOCK DUMPER. See Trestle man.

STOCK-HOUSE MAN. General term for anyone working in stock house.

STOCK UNLOADER. Laborer who unloads ore, coke, or stone from cars on trestle.

STOVE TENDER. One who puts stoves on gas or on blast, regulates temperatures of blast; handles gas at shutdowns; usually watches water from tuyères, plates, etc.

SWEeper. One who cleans the brick pavement between stock house, stoves, and furnace.

TAPPING BAR. See Picking rod.

TRANSFER-CAR MAN. One who operates electric car which transfers ore from ore bridge to ore bin.

TRESTLE LABORER. See Trestle man.

TRESTLE MAN. One who unloads coke, limestone, and ore. Keeps bins poked down.

TROUGH MAN. One who takes care of runner at pig-casting machine while iron is being poured from ladle cars; bars out scrap and keeps nose clean; prepares runner for next cast.

TURN MAN. An employee who works regularly at various stated occupations six days a week, enabling each of the six men he relieves to get off one day in seven. Cast-house turn man may work as hot-blast man, keeper, first helper, second helper, monkey boss, and cinder snapper.

TUYÈRE MAN. Fits up tuyères, plates, and coolers and tests them, to have them ready for replacement in furnace on short notice. Changes bronze when it cracks or is burnt.

WATER TENDER. A boiler-house employee attending to feed water of boilers, and usually also to blow-off valves. Frequently is foreman of the house and has charge of gas.

WELSHMAN. A heavy steel ring about 3 or 4 inches inside diameter, used in withdrawing a bar which is stuck or frozen in a skull of iron. The ring is placed on the bar, a wedge inserted, and the bar backed out by sledgeing on the wedge.

WINDING BAR. The appliance on drop-bottom cars by which the doors are closed and held tight.
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