SAFE FOUNDRY PRACTICE

THE TRAVELERS INSURANCE COMPANY
HARTFORD, CONNECTICUT

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PREFACE

The foundry, viewing it from all angles, presents one of the greatest problems in the industrial world. The fact that the production of castings depends not only on a mechanical process, but also on a chemical process, makes it specially difficult to fasten upon any individual the responsibility for imperfect work. And yet there is a definite (even though unassignable) reason for the loss of every defective casting produced, —some one member of the department failed in properly performing his part of the work. Every man must therefore be taught to appreciate the importance of his own particular task, and must be impressed with the necessity of performing that task conscientiously, and as correctly and efficiently as he can. There should be a spirit of cooperation as earnest and sincere as that which prevails in a beehive, where every worker performs the task of the moment with singleness of purpose, and with no thought or motive other than the production of the best final result, from the united labors of all. The development of a point of view of this nature among the men will also have a profound effect in the way of reducing accidents,—a greater effect, in fact, than could be realized by any other single means.

One of the problems that must receive special consideration in connection with accident-prevention work in foundries relates to the class of persons employed. It is not necessary to employ skilled labor for all the operations in the foundry, and for that reason a certain portion of the work is intrusted to unskilled help,—to men, namely, who do not understand the necessity for safety methods. The most practical and effective way of dealing with a situation of this kind is to adopt the team-work idea—that is, to teach co-operation—and to introduce a well-organized safety department that will educate the men to the extent of developing in them sound and correct accident-prevention ideals. Useful practical suggestions for accomplishing this, and for making the accident-prevention work effective, are given in a booklet entitled "*Organization in Safety Work*", which is published by the Engineering and Inspection Division of The Travelers Insurance Company.

Even the best-equipped, most orderly, and most effectively organized foundry is not free from accidents, and it is too much to expect that complete immunity will ever be possible. The experience of many concerns that have adopted safety methods in their foundries shows, however, that it is possible to eliminate a large proportion of the commoner causes of accidents, without much expense and without any serious disturbance of existing conditions. The Engineering and Inspection Division of The Travelers Insurance Company, in the course of its extensive experience with foundries, has given a great deal of study to this subject, and the recommendations and suggestions that it has made in the course of its practical inspection work have been well received by foundry managers, and have been particularly effective in bringing about better and safer conditions. The present booklet, based upon this study and experience, contains some of the suggestions that have been found to be most serviceable and important in dealing with the accident-prevention problem in its broader phases. Every foundry has important special safety problems of its own, which must be dealt with effectively if the best results are to be obtained; but to include all features of this kind would swell this booklet to such dimensions that its effectiveness and usefulness would be impaired. We have therefore confined our attention to danger-points of wide and almost universal occurrence.

There are few machines in foundries in comparison with the number in industrial plants of many other kinds. The machines that are used, however, must be provided with guards at all points where accidents might occur, and the necessary special guards have been described in more or less detail in the following pages. The construction and arrangement of the various forms of guards for belts and pulleys are not fully explained, but it should be understood that these are to comply with the standards approved by the Industrial Compensation Rating Bureau. The Engineering and Inspection Division of The Travelers Insurance Company will furnish upon request, copies of an illustrated pamphlet entitled "*Industrial Standards,*" which clearly explains the requirements of the Bureau.

In the main, the present booklet deals with iron foundries; but we have also included certain special hazards that are encountered chiefly in foundries where other metals are cast.

The Travelers Insurance Company,
Hartford, Connecticut.

CONTENTS

SAFE FOUNDRY PRACTICE

Introductory. According to the best statistics available, it appears that about eighty per cent. of the injuries received in foundries are in the nature of burns of greater or lesser severity; the remaining twenty per cent. being caused by defective hooks, chains, slings, flasks, mold-boards, bottom-boards, and other equipment, and by unguarded machinery, by falls and falling objects, and, indirectly, by inadequate illumination, poor ventilation, and other similar general conditions. Suitable clothing and shoes will materially reduce the severity of foundry burns, and will entirely eliminate many of them. Approved protection of this kind is described in the following pages, together with safeguards for various machines, and advice is also given with regard to precautions to be taken for the prevention of accidents in handling the various tools and appliances that are used in foundries.

Clothing. Suitable clothing is an important factor in protecting foundry workers from burns. Ordinary cotton shirts and overalls afford but little protection, because molten metal burns through them almost instantly; and although the legs and feet are the parts of the body most often burned in the foundry, it is advisable for the men to wear shirts (as well as trousers) made of a thick, stout, hard-finished material, such as khaki (twilled cotton), which will shed the molten metal to some extent. The bottoms of the trouser-legs should never be rolled or folded up, and there should be no other folds, nor any creases or pockets in the clothing, in which molten metal or highly-heated particles of any kind may lodge. Torn garments and those having holes in them are unsafe, and should not be worn. Woolen undershirts furnish the best protection against "shot" or molten metal, but on account of the intense heat to which foundrymen are exposed it is hard to get the men to wear them, particularly during the summer months.

Shoes and Leggings. The number of burns received by foundry workers on the feet and legs may be greatly reduced or almost entirely eliminated by the use of proper shoes and leggings. These should be worn by every foundry worker who has to handle molten metal, or who is exposed to it, and no one should be permitted to work without them, where the danger of such burns exists. Strong, substantial, well-made shoes of the "congress" type are the most suitable for general wear in foundries, because when they are in good condition they contain no holes through which molten metal may enter, while in laced and buttoned shoes there are many such openings. Moreover, congress shoes may be quickly and easily removed when hot metal is spilled upon them. Low-cut or Oxford shoes should never be worn by foundry workers.

Suitable leggings are almost as necessary as good, serviceable shoes. Under some conditions safety requires that the leggings be of asbestos or leather, but for general foundry work canvas or twilled cotton of good quality may be used. These materials will meet with all but the most severe requirements. The leggings, like the shoes previously described, should be fastened in such a way that they may be quickly and easily removed, and ordinary buckles are therefore unsuitable. Laces and buttons are likewise unsatisfactory, and any type of fastening that forms projections upon which molten metal may lodge does not afford the best sort of protection. Flat spring clasps, properly inclosed, at the top and bottom of the leggings, are the most satisfactory type of fastening devised up to the present time. The leggings should completely incase the legs from the knees down, and should fit snugly, especially at the top, to prevent the entrance of molten metal at this point.

Eye-protectors. It is extremely important to protect the eyes of foundrymen against the intense light and heat from molten metal and from welding flames, and also against dust and grit, flying chips, and molten metal that may be splashed about. Eye-protectors (also called "safety glasses" and "goggles") of various types are now available for all the different hazardous operations in foundries. To insure comfort, eye-protectors should fit well, and should be light in weight and easily adjustable for size. They should be provided with side protectors composed of metal screens or of perforated leather, to stop flying particles and small objects that might otherwise enter the eyes from the sides. The lenses should not be made of ordinary window glass, but in order to prevent serious eye strains they should be made of clear glass without flaws, and polished on both sides. They should also be strongly framed, so that pieces will not enter the eyes in case the lenses are broken. The lenses of eye-protectors that are to be used by furnacemen, welders, and others whose eyes are exposed to unusually brilliant light-sources should be suitably colored, to temper the intensity of the rays and to exclude those that are specially harmful to the eyes.

Experience has shown that where eye-protectors have been provided and worn faithfully, there has been a marked decrease in the number of eye injuries.

Gloves. Cupola men and others working where the heat is intense must provide protection for their hands and arms. Gloves and sleeves of calfskin, buckskin, canvas, and asbestos are used,—the choice of material depending upon conditions. When gloves with gauntlets are used, the sleeves of the shirt, coat, or jumper (whichever is worn) should be pulled down *over* the gauntlets. The sleeves should then be arranged with as few folds or creases as possible, and be secured about the wrists by means of buttons or clasps or in some other suitable manner. (By leaving the gauntlets *outside* of the sleeves lodging places for molten metal are provided, and serious burns are likely to result.) There should be no slits or openings in the lower ends of the sleeves (at the wrists) as in ordinary shirts, because molten metal would be likely to find entrance through them.

Hand-leathers and gloves of various kinds must be worn by men handling scrap, pig iron, and hot castings; and rubber gloves are important to afford protection against acids employed in pickling processes. Thick, clumsy gloves, which interfere with the safe handling of tools and implements, should not be used. Care should be taken to see that no workman wears ragged gloves, or gloves with frayed fingers, which are specially likely to be caught by moving parts of machines or on the sharp edges of objects being handled.

Aprons and Rubber Boots. In connection with pickling processes, rubber boots and rubber aprons are often necessary to prevent acid burns and damage to clothing. Aprons are of value in other departments of foundries also, particularly when flasks and rough, hot castings and other objects are being carried about, and when it is necessary for grinders to support castings in position at the grinding wheels. For work of this kind, and for foundrymen engaged in pouring metals, leather aprons are recommended. In view of the high cost of good leather, however, aprons of other suitable material may be used where the leather is not absolutely required.

Ladles. Several types of ladles are used in foundries, including reservoir, crane, sulky or buggy, trolley, bull, and single-hand ladles. Many burns are caused by defects in ladles, and by lack of care in handling and transporting them. All ladles should be frequently, regularly, and critically examined, and when defects are observed the ladles in which they are found should be immediately set aside for repairs, or should be discarded if the defects are of a serious nature.

Reservoir ladles and all other ladles operated by gearing should receive special attention. The motors of motor-operated ladles should be completely inclosed, not only to protect the workmen against electric shocks and burns, but also to prevent accidents which might be caused by metal being spilled upon the motors, resulting in short circuits or other kinds of trouble. All the gears on geared ladles should be completely inclosed, the covers or guards being constructed in such a way that they may be readily removed for oiling, cleaning, and inspecting the various parts. If guards are

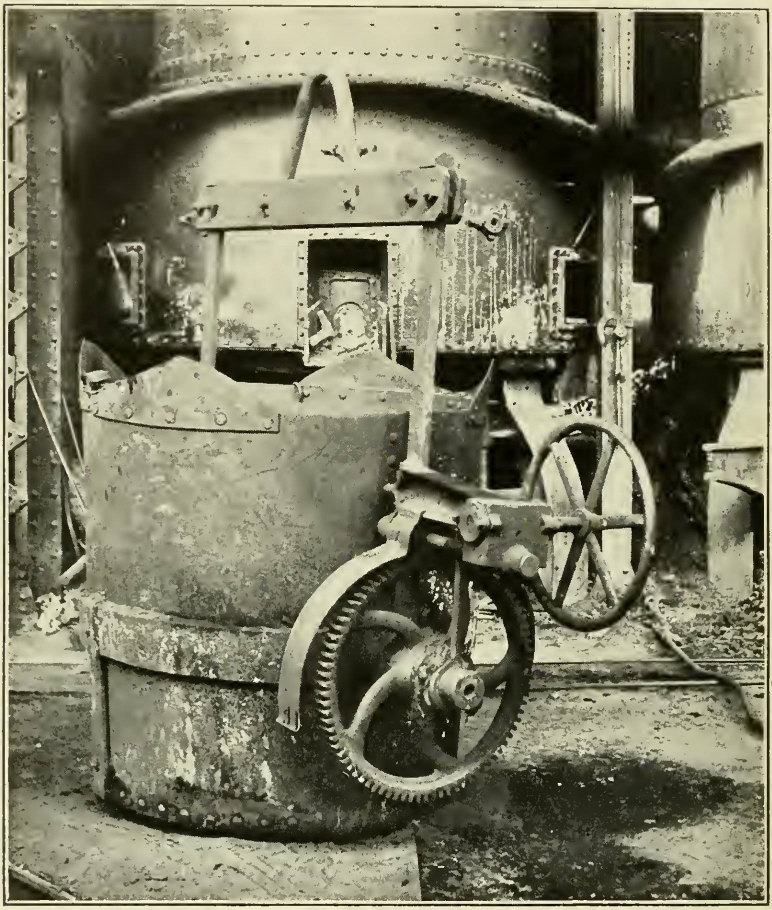

Fig. 1. A Crane Ladle.

(The gears should be completely inclosed, to prevent them from becoming clogged with dirt and spattered metal.)

not provided the gears will soon become clogged with dirt and with metal that has hardened or set after having been spilled upon them while in a molten state; and clogged gears are likely to be broken or stripped, and to cause serious accidents.

Many ladles are equipped with direct-acting spur gears. This arrangement permits rapid operation of the ladles, but it often imposes severe strains upon the operators, making it difficult for them to hold the ladles steady while pouring. This often results in spilling the metal and causing it to be spattered about when it strikes the sand on the tops of the flasks. A tilting arrangement composed of a train of spur gears, or a combination of worm gearing and spur or bevel gears, is to be preferred. The gears should be so designed and arranged that at least two teeth of each wheel will be in mesh at all times. Unless this point receives due attention a serious accident is likely to occur if the teeth become badly worn, or if one of them should break, thus permitting the ladle to tilt suddenly when pouring. The small pinions and worms of geared ladles often deteriorate quite rapidly, and they should therefore be inspected frequently and with special care, so that they may be renewed before they become a source of danger. Every geared ladle should be provided with a safety locking device to hold it in an upright position while it is being carried.

The bail of each crane ladle should be examined frequently, and particularly at the point where the crane hook engages it, because that is where the wear is greatest. The lower parts of these ladles should also be watched carefully for evidences of injury caused by carelessness on the part of cranemen when transporting or depositing them.

Sulky and buggy ladles are used only to a limited extent, but they cause many accidents. In some foundries steel plates are laid to serve as runways for buggy ladles, and plates are often placed between the rails of narrow-gage industrial railway tracks also. Molten metal is sure to splash when spilled on clean, smooth plates of this kind, and it also forms into "shot" which roll under the feet and cause the men to fall or to spill more metal. The danger from splashing might be minimized by sprinkling sand on the floor, but the sand would hinder the free movement of the wheels, and greater effort would be required to move the buggies. This would tend to make spills more frequent, even though in any individual case the sand might reduce the likelihood of injury from splashing, after the metal had been spilled. Floors of concrete and brick have been tried in other foundries, with the result that

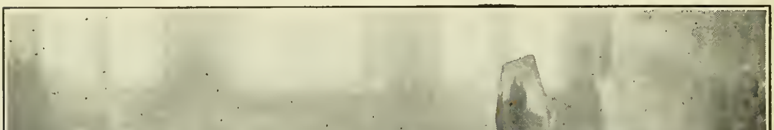

FIG. 2. A BUGGY OR SULKY LADLE.

(Observe the inclosure for the gears, and the shield to prevent the molten metal from splashing on the operator when pouring and when pushing the ladle along the track.)

the number of burns from spills has been materially reduced. An excellent floor may also be constructed of metal plates with *checkered surfaces*,—the elevations on these plates providing a surface that is sufficiently smooth for the wheels, while the depressions (which are filled with sand) tend to check the splashing. Overhead trolley systems are used in some foundries for transporting ladles, and in this way the spills and splashes that are due to poor floor conditions are eliminated.

It is necessary to maintain a clear path for buggies that are being moved about, because metal is likely to be spilled from them if even a very small obstruction is encountered. Moreover, the buggies or trucks should be inspected frequently, paying particular attention to the wheels and bearings to make sure that they are in good condition so that the buggies will run easily and smoothly. Each buggy should be equipped with prong guards to hold it rigidly while pouring, and the ladle should be properly counterbalanced so that it will automatically return to an upright position when empty.

Bull ladles are much safer to handle than ordinary single-hand ladles, and should be used whenever possible. Several styles of shank-handles are used with bull ladles, one of them consisting of a rigid fork handle on one side and a rigid single handle on the other side. In another style (which is preferable) both handles are forked; and in still another form a swivel is provided at one end, which permits the ladle to be tilted more easily and emptied with less danger of spilling. The bowls of bull ladles should be held securely in position in their shanks by means of clamps made of round or flat iron. The shanks must be amply strong for the

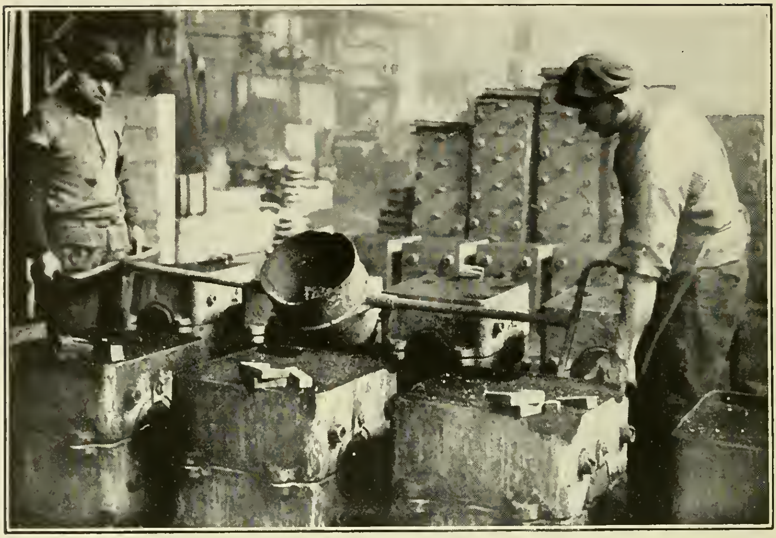

FIG. 3. A BULL LADLE IN USE.

(The handle is provided with a swivel, and one man tilts the ladle while the other man simply sustains a part of the weight.)

weight to be carried, and the joints should be carefully inspected for poor welding, flaws, and other weaknesses. Defective ladle shanks should be removed from the pouring floor as soon as discovered, so that there will be no possibility of using them again, either intentionally or otherwise. Ladle shanks should not be left exposed to the weather, because such exposure causes them to corrode and become weakened.

When single-hand ladles are used the shanks should be securely attached to the bowls, because otherwise the bowls are likely to slip out when pouring, and to cause accidents. A sheet-metal guard or shield, 6 or 8 inches high, should be firmly secured to the top of the bowl of every hand ladle on the side next to the shank, to protect the workman's hand while carrying the ladle.

FIG. 4. POURING FROM A HAND LADLE.

(This illustration shows the correct attitude for a man to assume when pouring. Observe also the shield on the ladle, to protect the hand from burns caused by spattering metal. The leggings are of a good type but, unfortunately, are not clearly shown. On general principles we disapprove of the unbuttoned vest, although the upper part of the body is unlikely to be burned so long as the man is engaged solely in work of the kind here shown.)

When several workmen are carrying ladles from the cupola to the molds it is better for them to pass on the side on which the bowls are carried. This not only tends to avoid confusion and disorder, but it is also safer, because there is less danger of burns when two bowls are struck together by passing workmen, than there is when two shank-handles collide.

"Horse play" and purposeless activities of other kinds should not be permitted among the men who are waiting their turns at the cupola, because the work is hard and dangerous, and the men must take it seriously at all times and give their undivided attention to it, if burns are to be avoided. The ladles should never be completely filled, because if they are, the hot metal will surely spill while being carried. "Cutting in" from the *back* of a continuous stream of molten metal at the cupola spout causes unnecessary spattering; always cut in from the front.

New employees in foundries, and particularly the unskilled help, should be carefully instructed with regard to the proper method of carrying the ladles and the correct position to assume when pouring into the molds, and they should be watched and supervised for a considerable time after being assigned to such work, in order to make sure that they understand how to do it properly. The men should stand at a safe distance from the molds, so that their feet will not be burned if the metal spills or runs out between the cope and the drag or nowel.

Ladles of all kinds, except hand ladles, are likely to cause accidents by tilting unexpectedly, unless the bowls are properly balanced on their shanks or trunnions, or are arranged to be locked in an upright

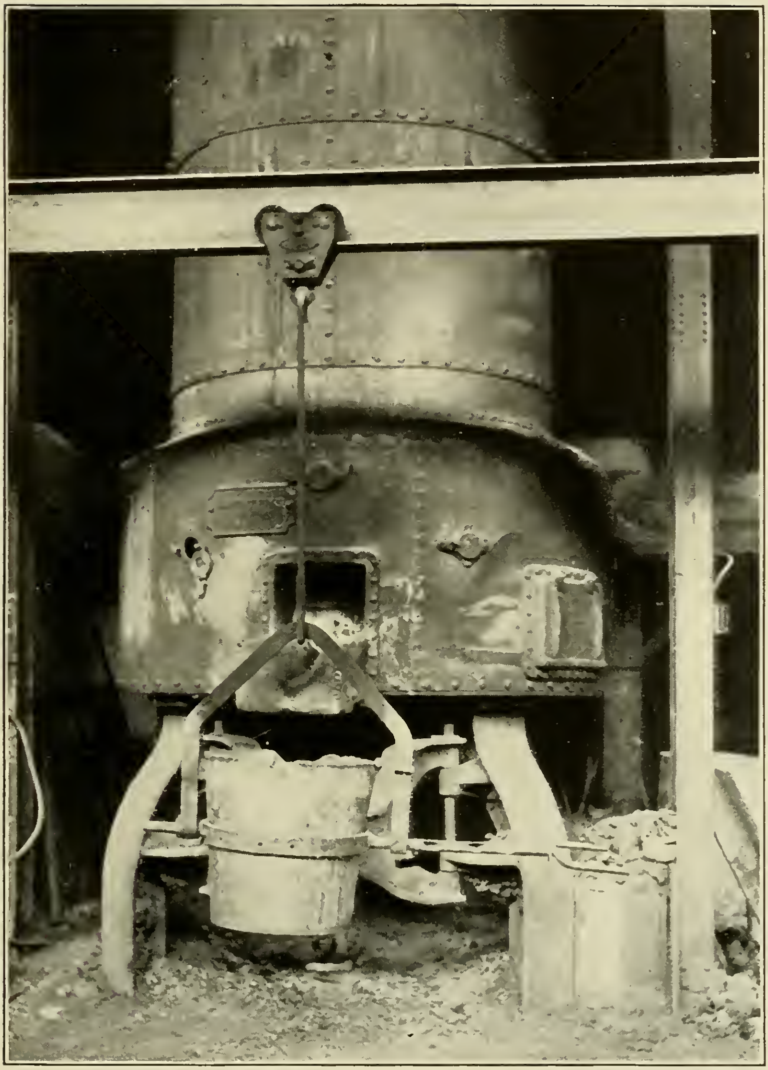

FIG 5. A TROLLEY LADLE IN POSITION AT THE CUPOLA.

position. It is specially important to see that the bowls are not top-heavy, even when full of metal. On the other hand, if the bowls are weighted too heavily at the bottom it is difficult to tilt them, and an unnecessary strain is imposed upon the operator and also upon the gearing and other mechanism; furthermore, it is not easy to pour a smooth, continuous stream from a ladle which requires considerable exertion to hold it in the pouring position. In particular, all ladles that are provided with bails for hoisting and transporting by cranes should be so constructed that, when full of metal, the center of gravity will be well below the bail, unless they are arranged with geared devices for tilting. In addition, they should be provided with clips or clamps to prevent unexpected or accidental overturning.

When buying new ladles it is important to see that the lips are of the correct shape to insure a smooth, narrow, undivided stream at pouring, and to prevent the molten metal from backing up and running over the sides at other points. Both safety and efficiency are promoted by the use of ladles with proper lips.

"Leave-overs" (excess metal left in ladles after the molds have been poured) are sometimes poured on the foundry floor. In this way puddles of molten metal are left, which soon become covered over with a thin coating of sand or dust so that they are not readily observed. The consequence is that men are often severely burned by stepping into or upon these puddles while the metal is still hot. Pouring leave-overs on the floor should be prohibited, and suitable receptacles should be provided at convenient points to receive the excess metal.

Many serious accidents have been caused by pouring molten metal into damp ladles, the result usually

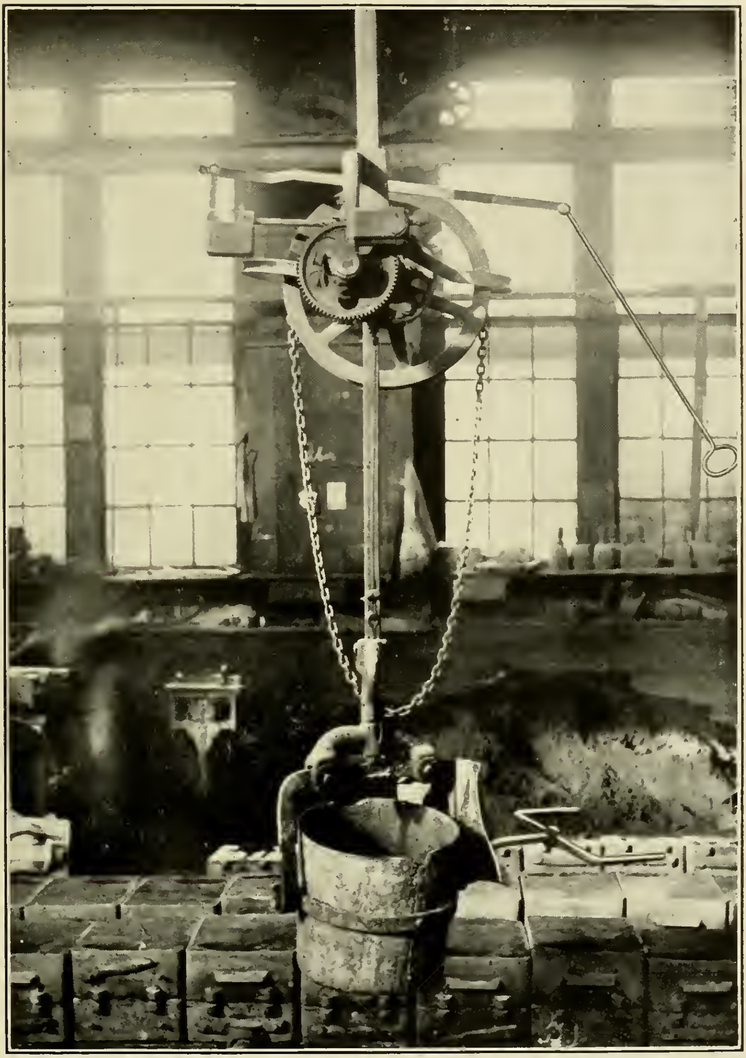

FIG. 6. A CONVENIENT LABOR-SAVING POURING DEVICE.

(By installing a monorail system a device of this kind can be used for main-aisle and side-floor work. It can be operated by one man, with safety. The ladle can be hoisted and lowered, thus making it possible to pour molds at various heights. The metal shield protects the eyes of the operator against heat and glare, and also prevents burns from spattering metal.)

being an explosion, and the scattering of the metal in all directions. In every foundry, therefore, special care should be taken in drying the ladles. In some plants the core ovens or crucible furnaces may be utilized for the purpose, while in other cases it may be necessary to provide special ovens or heaters. Ladles should not be dried in the molding rooms by means of wood fires, unless adequate exhaust ventilation is provided.

All ladles that are not in use should be stored in a dry place, and preferably on elevated racks, or on supports of some other kind that will permit the air to circulate freely about the ladles.

Foundry ladles must be relined from time to time (bull and hand ladles are relined each day), and it is advisable to have all of this work done by men selected for reliability and experience, who are interested in making the ladles safe and willing to give them the necessary time and attention.

All of the ladles that are in use should be examined carefully every day, preferably by an experienced and conscientious man who has been specially selected for this work. The bowls should be inspected for cracks and thin, weak spots, and the shanks should be examined to discover defective welds and erosion. Inspectors should also look out for loose rivets and bolts, and should see that all necessary guards are in good condition and properly secured in place, and that all ladles are properly balanced.

Flasks and Molds. Wooden, steel, and iron flasks are used in foundries, but those of iron and steel are so much superior that preference should be given to them under all possible circumstances. Iron flasks may be cast in the foundry, and the subsequent maintenance and depreciation charges are quite small as compared with what must be expended upon wooden flasks. Moreover, after a wooden flask has been used for some time the faces of the cope and the nowel become burned or broken off, with the result that instead of fitting closely together they may be separated by a space of an inch or more. Although this space is filled with sand, the hot metal is likely to break through and run down the sides of the flask. "Run-outs", as leakages of this kind are called, often cause severe burns on the feet and legs of the workmen. If iron or steel flasks are used, and the cope and nowel faces are planed to insure a close fit, there will be little likelihood of the occurrence of run-outs.

Iron and steel flasks, as well as wooden ones, require frequent and careful inspection to see that none of the lugs, handles, or other parts are broken. If a flask is found with a broken or cracked lug or handle it should be immediately removed from the shop for repairs; otherwise, it might be used again by some person unaware of its dangerous condition, and a serious accident might result when it was picked up by the crane.

Congestion on the molding floor is noticeable in many foundries, particularly in those where the work is greatly diversified; and numerous burns are the direct result of such a condition. Sufficient space should be left between flasks so that the molders and their helpers will not be crowded while pouring, and so that they will be able to get out of danger quickly and easily in case of a "run-out". There should always be a clear space of at least 18 inches between the rows of flasks when pouring "side floor" by hand, and for crane work in general; and passages 24 inches or wider are much to be preferred. Portable horses may sometimes be used to advantage for supporting bull ladles when pouring work of certain kinds.

Flasks, when in storage, should be piled in an orderly and systematic manner, and the maximum height for stacking them should be such that the workmen can handle them easily and conveniently while standing with both feet on the floor. Unevenly piled flasks sometimes fall over and cause serious injuries; and even though they are piled well enough to be stable if undisturbed, they may fall in consequence of jarring due to the motion of neighboring cranes, and sometimes they are pulled over by chains dangling from the cranes.

Workmen often collide one with another, and are severely burned or otherwise injured, in consequence of their view being obstructed by foundry equipment. Obstructions likely to cause accidents of this kind should be moved to the sides of the room. It is highly essential, also, to keep all the aisles clear of flasks, tools, implements, and other obstructions, particularly in plants where the illumination is not of the best, and where, on account of insufficient ventilation, large quantities of smoke obscure the vision.

Orderliness and adequate light and ventilation not only increase efficiency, but also materially reduce the number of accidents; and any reasonable expense that is involved in securing good conditions in these respects will pay for itself by lessening the time that is lost in consequence of the temporary demoralization to which the working force is subject whenever an accident occurs.

Crucibles. Crucibles are extensively employed in founding, especially in connection with non-ferrous metals; and the importance of exercising special care in handling them, not only to avoid accidents but also to insure greater length of service from the crucibles themselves, has been greatly under-estimated in the past. In our larger plants, however, foundrymen are now giving considerable attention to the systematic instruction of their furnacemen, melters, and helpers, with a view to keeping the number of accidents as low as possible, and obtaining as great a number of heats as practicable from each crucible.

The clay crucibles of former days have been extensively supplanted by better ones made largely of graphite, which is capable of resisting exceedingly high temperatures. In fact, crucibles composed wholly of clay have practically gone out of use for the melting of steel and brass, because they can often be employed for only one or two heats, and they are far more likely to break or crack unexpectedly, thereby causing workmen to be seriously burned. Moreover, the temperatures that occur in metal-working plants at the present time are higher than those that prevailed when the all-clay crucible was the standard type. The crucible that is now in general use consists mainly of the substance that is variously known as graphite, plumbago, or black lead, and which is a practically incombustible form of carbon. This is combined with a small amount of a special variety of clay as a binding material, and perhaps a little fire sand to give the mixture an open grain, so that it can better withstand sudden changes of temperature. Some makers use, in addition, a certain quantity of material obtained by grinding up old, worn-out crucibles; but this practice cannot be recommended.

The graphite crucible is doubtless the most efficient yet devised, when cost and all other elements are considered, but it is nevertheless somewhat fragile, in view of the fact that it is expected to withstand a heat sufficient to melt the refractory metals, and to support, at the same time, very considerable pressures due to the weight of its heavy fluid contents. It is exceedingly important, therefore, to see that all employees fully understand how to handle crucibles in order to reduce the danger of breakage to a minimum; and a great deal can be accomplished in this direction, because graphite crucibles, when properly made and carefully used, can be kept in a fairly safe condition.

The number of accidents from breakage is greater in small plants than in large ones, in proportion to the number of crucibles in use. This is due partly to the greater care that the crucibles receive in the large plants, and partly to the fact that large foundries buy supplies of crucibles considerably in excess of their immediate requirements, storing the surplus ones and allowing them to age or "season". It is an old saying that crucibles improve as they grow older, and as experience shows that this belief has some actual basis in fact, the date of manufacture should be stamped upon every crucible, to assist the annealing men in selecting the oldest and best seasoned of them, when additional ones are required for use.

Good crucibles are expensive, and every foundryman therefore desires to obtain the maximum service from them. The foundryman who attempts to increase the useful life of his crucibles by careful handling, and by the adoption of approved methods of every other kind, is at the same time promoting safety by preventing accidents from premature breakage. Foundrymen, melters, pourers, and helpers, usually expect a crucible to run a certain definite number of heats, and they are likely to be somewhat careless

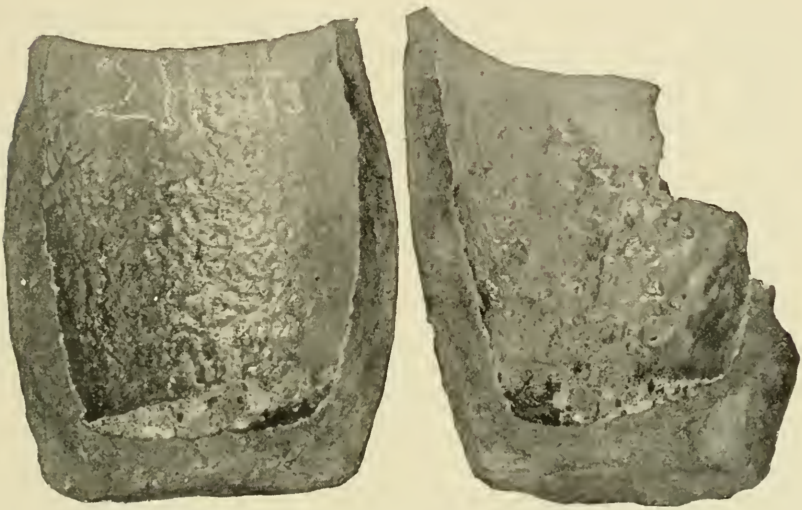

FIG. 7. A CRUCIBLE WHICH BROKE AFTER BEING RUN ONLY TWO HEATS.

when a new crucible is put in service. For this reason it is wise to assign a number to each crucible, for recording the number of heats taken. The record may conveniently be kept upon a black-board, opposite the appropriate crucible number and in plain view. Everybody then knows just how many heats each crucible has run, and this knowledge often arouses a spirit of competition, which tends to make the men more careful in handling the crucibles, and to increase the service that can safely be had from them. (The dating and numbering here recommended are now being done, quite generally.)

When crucibles are first received, it is important that they be critically examined for cracks and flaws, not only by the eye but also by tapping them with a light hammer; and all imperfect ones should be rejected. If there is evidence that any of the crucibles in a given shipment have become wet while in transit to the foundry, they should be stored for at least four or five weeks, before being used, in a place where they will dry out thoroughly—even though they may be apparently dry at the time they are received.

When a new supply of crucibles has been carefully inspected and found to be free from defects, the entire lot should be stored for a considerable time in a warm, dry place, and provision should be made to protect them as thoroughly as possible from contact with moisture or with moist air. The roof of a continuously-operating core oven is an excellent place for the storage chamber.

The proper annealing of crucibles is of far more importance than is generally realized. It is said that crucibles, when they come from the manufacturer's kilns, contain less than one-quarter of one per cent. of moisture; but after they have cooled off they absorb moisture again from the air. To anneal a crucible properly, it should first be slowly heated to a temperature somewhat above 250° Fahr., and it should be maintained (or "soaked") at this temperature for a sufficient time to entirely remove the moisture. It may then be put into service, if it has been thoroughly annealed by the makers. If there is any doubt on this point, however, the crucible should next be heated for some hours to a dull red heat, after which it should be allowed to cool again, very slowly, to about 250°. In any case the crucible should still be at a temperature of 250° or over, when it goes into the furnace, or the drying-out process will not be wholly successful.

Large crucibles, with thick shells, require a higher temperature than small-sized ones in the preliminary heat-treatment, and a correspondingly longer "soaking" period, in order to reduce the absorbed moisture to the allowable limit. In drying out a No. 200 crucible, for example, ten hours or more should be allowed for bringing it up to a temperature of 250° Fahr., and fully ten hours more should be allowed for "soaking", —that is, for reducing the percentage of moisture which may have been absorbed. If a crucible that has a considerable amount of moisture in its walls is quickly subjected to a high temperature, the moisture will be changed into steam, and this, because it is confined within the walls of the crucible, may expand so as to cause a rupture or crack. The same result may also follow from the natural contraction of the drying crucible, if the moisture is driven out rapidly or unevenly. The small "pinholes" and "skelping" that may often be seen on crucibles are caused in this way. These pinholes and fissures form one of the chief sources of trouble against which users of crucibles have to guard; for although a crucible having defects of this nature may endure for a considerable number of heats, it is nevertheless likely to fail at a critical time (for example, during pouring or while being pulled from the furnace), spilling the molten metal and causing severe hand and foot burns.

After receiving heat-treatment for the removal of moisture, crucibles are often placed on a layer of damp sand, or on the comparatively cold furnace floor, and left there for an indefinite length of time before charging. This should not be permitted, be-

FIG. 8. THE CRACK IN THIS CRUCIBLE DEVELOPED AFTER FIVE HEATS.

cause when the temperature of the crucible falls to a point materially below 250°, it will again absorb moisture.

Fine cracks (called "alligator cracks") often cover the entire surface of a crucible. These may be caused in a number of ways. Sometimes they are due to heating the crucible with fuel containing too high a percentage of sulphur; or, in oil furnaces, they may be caused by using too little oil or too much steam. It is specially important for the operators to thoroughly understand their work when using an oil furnace, because an excess of air or steam, or an insufficient supply of oil, may give rise to an oxidizing action, whereby a portion of the carbon (or graphite) is burned out of the crucible wall, leaving the binding clay in a somewhat porous condition; and this action, when it occurs, greatly facilitates the formation of cracks.

When crucibles are stored on the top of a furnace, the melters or furnacemen should make sure that the covers over the furnace openings fit properly. If the furnaceman is careless in this respect the moist gases that are given off when fresh fuel is placed on the fire will escape through the openings to some extent, and they are likely to come in contact with the crucibles, causing alligator cracks to form.

Cracks and fissures are also likely to form if the metal to be melted is not carefully placed in the crucibles. The men usually work rapidly when introducing the ingots, so that the furnaces will not be left open any longer than necessary; and the ingots are often thrown in with a force sufficient to indent the bottoms of the crucibles, or otherwise damage them. An indentation in a crucible, whether caused in this way or in any other way, is quite likely to develop, shortly, into a crack or fracture. The ingots should be introduced carefully and loosely, sufficient time being taken to insure that this is properly done. When a crucible is first filled it is desirable to place as many ingots in it, for the first melting, as practicable; but it is exceedingly important to see that they are not wedged or jammed, because when they are heated they will expand more than the crucible itself, and the walls of the crucible are likely to be cracked in consequence.

When a new crucible is put in service for melting, it should be heated quite slowly for a few runs, and this is *specially important the first time it is used.* After one or two runs it will become vitrified, and the danger from too sudden a heating is then materially reduced. It is a good plan to keep on hand a few extra crucibles that have been used before, to avoid loss of time in case an extra crucible is needed on short notice.

Fig. 9. A Carrying Pot, with Shank.

A great deal of harm is done by carelessness in handling the tongs and shanks, and the life of a crucible may be seriously shortened in this way. When a tilting furnace is used, as many as fifty heats can often be obtained from a crucible; but if the heating is in furnaces from which the crucibles must be removed by means of tongs, they can be used for only about fifteen heats, on an average.

A crucible is soft and plastic at a white heat, and may easily be squeezed out of shape by the pressure exerted upon it when the handles of the tongs are forced together. The walls of the crucible gradually become weakened by treatment of this kind, and eventually, if the crucible is not discarded, a complete rupture will probably occur, with its attendant toll of injuries and burns.

Three styles of tongs are in general use in foundries —one-pronged, two-pronged, and spade tongs. The different styles are designed for various special purposes

FIG. 10. TONGS PROPERLY APPLIED TO A CRUCIBLE, FOR REMOVING IT FROM A STATIONARY FURNACE.

and operations, but they are sometimes improperly used interchangeably. It is essential to see that the tongs that are used are of the proper shape, and that they fit perfectly from the widest part of the crucible (usually called the "bilge" or "belly"), down to within a few inches of the bottom. They should not extend to the *extreme* bottom, however, because this would make it hard to place the crucible in the shank. On the other hand, if they do not extend down far enough the crucible will be badly squeezed. The proper use of the tongs consists in taking hold of the crucible below the bilge and lifting it in such a way that the least possible pressure is exerted against the crucible walls.

One-pronged tongs should be used only for lifting the smaller-sized crucibles,—say up to size No. 40. For larger sizes two-pronged tongs should be used. It is not uncommon to see large crucibles, ranging from No. 200 to No. 300, lifted by one-pronged tongs. This practice should be condemned, because when one-pronged tongs are used for lifting a crucible, pressure is exerted against only a single point of contact,—namely, at the bottom,—and the crucible, when hot and soft, is likely to be cut or ruptured, if it is large and heavy, because the pressure at the point of support is severe. Serious burns, from the spilling of the molten metal, often result when the lower prong of a two-pronged pair of tongs is cut off, on account of a lack of space between the crucible and the furnace wall; because the crucible is then lifted from above the bilge, and tilted. Melters should be cautioned against the practice of driving down the ring of the tongs with a skimmer or other implement, because this is almost sure to cause cracks and fissures in the crucibles.

Molten metal is often spilled from crucibles in consequence of using tongs that have become bent or otherwise misshapen. It is important to see that the tongs fit the crucibles properly, and that they are also in good condition in every other way. For restoring bent tongs to their proper shape, it is advisable to procure a set of cast-iron forms similar in size and general shape to the crucibles that are used in the plant, but slightly larger from the bilge upward. To restore the tongs to their original form it is only necessary to put them in the furnace, raise them to a red heat, clamp them to the proper iron form, and bring them back into shape by means of a heavy hammer. Tongs may be fitted easily and cheaply in this way, and a great saving of time results. If cast-iron forms are not provided, the blacksmith cannot be expected to restore the tongs to their correct shape with accuracy; but if iron crucible-forms of the proper sizes and shapes are used, and the tongs are fitted to them as here recommended, the likelihood of squeezing and distorting the crucibles will be reduced to a minimum.

Two pairs of tongs, at least, should be provided for each size of crucible, so that if one pair becomes badly bent or worn, the other pair may be placed in service without loss of time.

Furnacemen should make sure that no clinkers or pieces of unburned coal or coke are stuck to the walls of the crucibles when about to grasp them with the tongs, because if the tongs are applied over a clinker the clinker will probably be forced into the crucible and a rupture may then occur at any moment. It is also important to see that the bottom of the crucible (on the outer surface) is free from clinkers or other adherent substances, so that when the crucible is in the furnace its weight will be evenly distributed, and not concentrated at a few projecting spots or regions. It is best to support the crucible by means of a foundation or pedestal, of graphite, fire-brick, or other infusible substance, though the fire-bed may be made to give a fairly satisfactory support if it is carefully prepared and smoothed.

When a heat has been poured it is important to see that no metal is left in the bottom of the crucible, because when a residual mass (or "button") of such metal cools, it contracts at a different rate from the crucible, and serious strains and cracks are likely to result.

Ramming the fuel bed is bad practice, in general, because it is likely to damage the crucibles seriously. If ramming appears to be necessary at special times, the utmost care should be exercised in doing it.

(We are indebted to the General Electric Company for the photographs that are used in this section.)

Cupolas. Tapping-out is the most hazardous part of cupola work. This is specially true if the melter is inexperienced or careless, for it is almost entirely within his power to prevent excessive spattering of the hot metal if he properly controls the flow from the cupola. If dangerous spattering of the molten metal, with its attendant burns, is to be eliminated, it is important that the melter be taught the correct and only safe method of stopping up the tap hole. Under no circumstances should the stopping bot be thrust directly into the stream of flowing metal in order to "bot-up" the hole. Instead of this, it should be brought immediately *over* the stream, and, when near the hole, should be carried down obliquely so that it will make a sharp angle with the stream, and thus effectively and instantly close up the hole without any undue spattering. In drawing molten metal from the cupola into buggy or trolley ladles, it is necessary to stop the flow of metal when a ladle has been filled and while another is being moved into position. This is done by the melter, who inserts the stopping bot into the hole and holds it there temporarily. After doing this several times the fire clay on the end of the stopping bot becomes burned off, and consequently the hole may not be closed properly. One or more extra stopping bots, already prepared with fire clay, should be conveniently at hand, which may be substituted for the burned-off one when necessary. The melter and all other workmen engaged about the cupola should wear well-designed goggles having side shields, because statistics show that a high percentage of eye injuries occur about the cupola.

Accidents occur about cupolas not only when drawing off the metal, but also during charging time, and when repair work is being done. As a general thing workmen engaged in charging a cupola must bring the coke and the iron (both scrap and pig) from the storage bins or yard, up to the charging platform. These workmen should be instructed to pile the iron evenly on the barrows, and to exercise great care in taking the scrap from the pile, in case the latter is in such a condition that it is likely to collapse or slide. Many workmen have been severely injured, while filling their barrows, by the sudden collapse of piles of scrap iron.

In many foundries elevators are used for conveying the charges to the charging floors. In every such case it is essential that a gong or other signal be sounded before the elevator is taken from the charging floor by a workman below; and the elevator should not be moved, after the signal has been given, until sufficient time has elapsed for any person who may be in danger to respond and to move into a place of safety. Many serious accidents have been caused by elevators suddenly descending while the workmen were loading or unloading them. To further guard against such accidents there should be a door or gate at each entrance to the hoistway, provided with an interlocking device so arranged that the elevator cannot be started until the door or gate has been closed. The unused sides of the car platform should be completely inclosed to a height of 6½ feet (or to the top of the crosshead), and a substantial iron grating should be placed on the top of the car, to stop falling tools and other objects.*

The charging opening in a cupola should be fitted with a door or gate, which should always be closed except when charging is going on, and workmen engaged in charging should be specially careful to avoid tripping or losing their balance when in the vicinity of the opening, and especially when throwing heavy pieces of scrap or pig metal into the cupola.

When the interior of a cupola is being relined it is recommended that a watchman be stationed near the opening, or that a conspicuous warning sign be posted beside it, stating that men are working inside. We have known of cases where metal thrown into the cupola has struck and seriously injured workmen who were engaged in making repairs to the shell or lining. An effective guard against accidents of this kind consists in a circular screen of a diameter slightly smaller than the inside of the cupola, and made of heavy wire

* Further information with regard to the care and operation of elevators in general is given in a booklet published by the Engineering and Inspection Division of THE TRAVELERS INSURANCE COMPANY. Copies of this booklet may be procured by applying to the Home Office at Hartford, Connecticut.

netting or of stout expanded metal, substantially framed. The screen should be divided in the center, and the two sections hinged together. In using this device it is suspended above the point where the men are at work, from a piece of scantling laid diametrically across the cupola so that it rests upon the walls where they are offset for the single brick lining, or upon the ledge formed by the charging doors,—the screen being supported by chains at several points around its circumference, and having its hinges on the under sides. When arranged in this way it tends to remain open and flat, although it can easily be folded by raising it at the middle. A screen of this kind will intercept falling pieces of slag and brick, and other objects, and will thus protect the workmen below.

When furnaces are to be entirely relined, only trustworthy and experienced men should be allowed to perform the work. Moreover, the fire-bricks that are used should be of the best quality obtainable, in order to insure long life of the cupola. Between the bricks and the shell a space of about $\frac{3}{4}$ of an inch should be left, which should be filled with dry sand to act as a cushion, so that severe stresses will not be thrown on the shell when the bricks expand. The rivets and the shells of all cupolas should be inspected periodically, to see if any of the rivets have sheared off or worked loose, or if the shell has become weakened in any way. After making repairs of any kind, care should be taken to see that the cupola is thoroughly dried out, and that all tools, and all materials used for scaffolding or other purposes, are removed.

Explosions occur in cupolas from time to time, and if the shell of a cupola is weak, a serious catastrophe is likely to result. Carbon monoxide, when combined with air in certain proportions, forms a highly inflammable and explosive mixture, and the explosions are mainly due to this gas, which collects in the wind box and blast pipe during interruptions in operation. In an incredibly short time enough carbon monoxide gas may collect in this way to cause a violent explosion when the blast is turned on again. If the iron comes too fast a temporary shut-down may be unavoidable; but interruptions from other causes,—such, for example, as the slipping of the blower belt,—should be prevented, so far as possible, by frequent inspections of the equipment and by making all necessary adjustments and repairs when the cupola is not in operation.

A gate or damper should be placed in the blast pipe, close to the cupola, to prevent the explosive gas from entering the pipe. This gate should be closed *immediately*, whenever the blast is shut off, and it should be opened cautiously and slowly when starting up again. At the time that the blower is shut down one of the tuyeres should be opened also, to maintain a slight draft of air.

Explosion doors provide another means for preventing damage from gas explosions. Some authorities recommend that these doors be placed in front of the tuyeres, so that when the blast is turned off the doors may be opened to admit the outside air. When this arrangement is adopted the doors should not be closed until the blast has entered the wind box, so that any gas remaining therein may escape through the doors.

With a positive-pressure blower, which is probably the best type for cupola work, a safety-valve should be provided for the protection of the blast pipe or blower.

This will prevent the bursting of the blast pipe in case the blast gate is closed suddenly, or if the cupola becomes clogged with slag in such a manner as to obstruct the passage of the air to a dangerous extent. The weights on the safety-valve should be sufficient to prevent blowing-off unless the obstruction is quite serious, because a constant blast-volume is required in modern cupola operation, and if the volume is decreased an undesirable lowering of the temperature occurs.

Charging and lighting-up should be done carefully and by experienced workmen, and the charges should be laid as nearly level as possible. When the charging has been completed, and after lighting-up, sufficient time should be allowed for the cupola to become thoroughly warmed up before starting the blower.

Traveling Cranes. Cranes of various types are used in the foundry, but most of the heavy work is done by electrically-operated traveling cranes. The suggestions that follow therefore relate mainly to that type, although many of them are applicable to all cranes, and to hoisting devices of other kinds.

A substantial stairway or ladder should be installed at one end of the crane runway, to provide access to the crane cab or cage; and when two cranes are operated on the same runway, stairways or ladders should be installed at both ends of the runway. Cranemen should always use this means of entering and leaving the cages. Every crane cab should be inclosed to a height of at least 42 inches on all sides, except where entrance is actually effected. The inclosure should preferably be of sheet metal or expanded metal, or of heavy, woven-wire mesh. If railings are used there should be an intermediate rail midway between the top rail and the floor of the cab, and a six-inch toe-board should also be installed. A stairway or a ladder should always be provided for passing from the cab to the top of the crane bridge. This should be substantially built, and properly protected so that the crane operator or repairman will be in no danger of falling when he uses it.

A foot-walk should be constructed along the bridge of the crane, or on both sides where the width of the bridge demands. This will give easy and safe access to the trolley in any position, and to any part of the bridge. The construction should be substantial, and the width must be sufficient to provide ample room for passage. Double railguards 42 inches high should be erected along each foot-walk, and six-inch toe-boards should also be provided.

Whenever possible, a substantial walk should be installed beside the crane runway, and this should be protected by strong railings and toe-boards along its entire length. All traveling cranes should be equipped with spring bumpers or oil bumpers, and suitable stops should be installed at each end of each rail of the runway.

All gears on the trolley and other parts of the crane should be completely incased, and no one should be allowed on top of the crane while it is in motion. A stout sheet-metal pan, or a substantial floor, should be provided under the trolley, to catch any parts that may work loose, and to prevent them from falling upon employees below. This pan or floor should be solid except for the cable openings. Guards, fenders, or brushes should be attached in front of the bridge and trolley wheels, to remove any obstructions that may be upon the tracks, and to prevent injury to persons who may be working in such positions that their hands or feet might be crushed by the wheels.

All electrical wiring should be installed in conduits; and it is particularly important that hoist-limit stops be provided, in all cases, both for the main and for the auxiliary hoists. In the best crane practice the hoist-

Courtesy of The Alliance Machine Company.

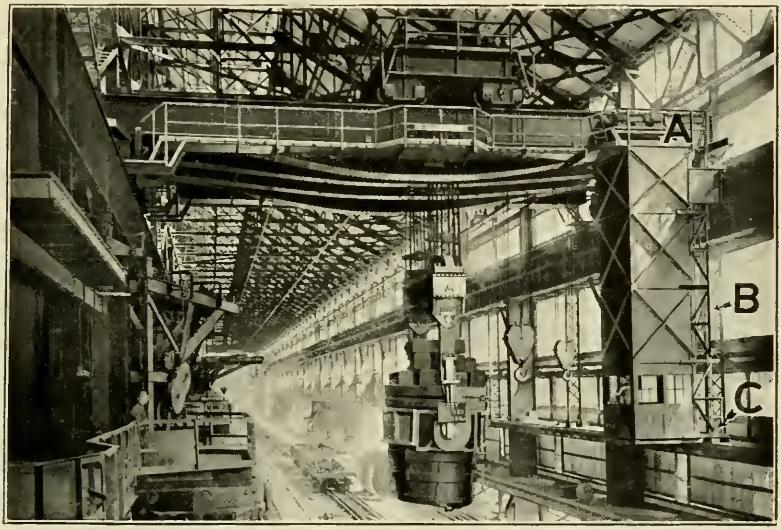

FIG. 11. SAFEGUARDS ON A LARGE LADLE CRANE.

(This crane is larger than is used in the average foundry but it has some safety features that should be universally adopted. At A is the landing platform leading to the foot-walk on the crane bridge; B is a stairway which extends from the safety platform. C, just outside the operator's cage, to the landing platform. The railing and toe-board on the crane bridge and on the trolley are also essential for safety.)

limit stops employ dynamic braking to check overtravel and to assist in lowering loads. To prevent the crane from being operated by unauthorized persons, or while repairs are being made, there should be a safety switch in the main line, mounted above the cab where it can be conveniently reached from the foot-walk. This switch should be fitted with a lock so that it can be secured in the open position, and the key should be only in the possession of the crane operator or the head repairman.

Woodwork should not be used about a crane, because it is likely to become oil-soaked, and it is then exceedingly combustible. If it should take fire and the craneman, in order to make his escape, should run the crane to a stairway, the time required for this purpose might increase his danger quite materially, and the

Courtesy of the Shepard Electric Crane & Hoist Company.

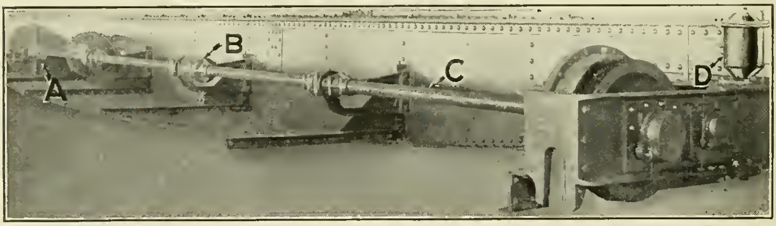

Fig. 12. Some Safety Features of a Traveling Crane.

(This illustration shows a part of a crane on the erecting floor of the manufacturer. There are no exposed revolving parts throughout the entire length of the crane bridge. Some of the safety features are as follows: A—inclosed gearing; B—inclosed drive-shaft coupling; C—pipe inclosure for drive shaft; D—device for sanding rails when crane is used out-of-doors. See also Fig. 13.)

motion of the crane would also tend to increase the fire. If, on the other hand, he tries to leave the crane in any other way than by the regular stairway, he will be exposed to hazards of other kinds, and these will be accentuated by his haste.

Keep all tools, oil-cans, and waste in a closed metal box securely fastened to the crane or to the runway at some convenient point.

Careful, watchful, intelligent, and trustworthy crane operators, floormen, and repairmen, can do a great deal toward preventing accidents, and only such men should be employed about cranes. The following suggestions relate to the work of these men, and if faithfully followed will be the means of promoting safety in a marked degree.

During the ordinary operation of an electric crane the craneman should never leave his cage without

Courtesy of the Shepard Electric Crane & Hoist Company.

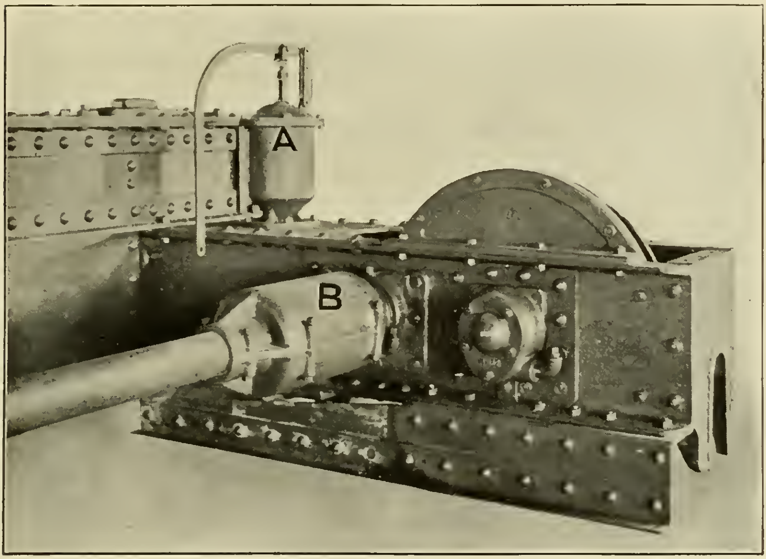

FIG. 13. SOME SAFETY FEATURES OF A TRAVELING CRANE.
(This is a nearer view of some of the safeguards shown in Fig. 12. A is the track sander which is operated by a rope or cable attached to the lever and extended to the craneman's cage; B shows more clearly the drive-shaft coupling. The shaft inclosure also appears more plainly.)

making sure that all the controllers are in the off position, and that the main switch is open. Before he leaves the crane the safety switch should also be locked open. If the electric current should be shut off at any time, the same precautions should be observed; and before closing the main switch, when about to resume work after an interruption due to any cause whatsoever, the craneman should again make certain that all the controllers are in the off position.

When about to lift a load, the motor should be run at low speed until the slack in the chain or cable has been taken up, after which the controller handle may be advanced slowly from point to point to increase the speed. Before a motor is reversed it should be brought to a full stop, except when an accident can be averted only by disregarding this advice.

When handling a heavy load the craneman should hoist it a few inches above the floor, and then, before proceeding further, he should assure himself that it is properly balanced and that the slings are secure, and should also test the brakes to make sure that they will hold the load safely. If there is any doubt whatsoever about the safety of the operation, the load should be lowered and the slings or brakes adjusted, or other necessary measures taken to avoid danger. It is also desirable, at the beginning of each shift, to test the foot brakes and limit switches thoroughly.

It is extremely important, at all times, and particularly when handling molten metal, to "spot" the trolley directly above the load to be hoisted. Failure to do this will cause the load to swing sidewise as soon as it is clear of the floor, and usually the metal will be spilled, or men or objects near by may be struck by the load.

Loads should be raised high enough to give proper clearance above men and objects on the floor, but they should not be carried for any considerable distance at an unnecessary elevation. So far as possible, the craneman should avoid transporting loads directly over workmen. Special care should be exercised to keep loads under control when lowering them, and the speed should always be restricted to a reasonable and safe limit.

Some definite person must be held responsible for the selection of the chains and slings that are used for hoisting, and for making suitable hitches about the loads. If the foundry is large enough to employ a special floorman, these matters may well be left to him, because he is necessarily familiar with the constantly-changing conditions, and he should therefore be able to select the proper sling quickly and intelligently. Moreover, experience will have taught him the best method for attaching the sling, or for hooking on to the load. If no special floorman is employed, this part of the work should be supervised by a specially assigned foreman, or by a skilled hooker-on. When applying the hook to the load, and when holding the hook in place while the slack is being taken up, the hooker-on should be careful to avoid having his hands caught and crushed between the sling and the load. Hooks with safety handles may be had, and these add greatly to the safety of the men when hooking up. If safety handles are not provided, pieces of wood notched at the end may be used with advantage for holding the hooks in place,—the notch being pressed against the hook to prevent it from moving before the tension comes on it.

When the hooks or slings are in place and the slack has been taken up, the workmen should immediately move back several feet from the load. When a load is being deposited, all persons should keep at a safe distance while the slings are being withdrawn from under it, because the slings may snap out suddenly, or may catch on the load and tip it over. When slackening-off the hoisting cables the hooker-on should avoid pulling down on the *inrunning* side of the block, because his fingers may be caught between the sheave and the cable and be cut off or badly crushed. It is far safer to grasp the outrunning side, and pull up and away from the sheave. Greater safety in this work is insured by inclosing the block to which the hook is secured. Blocks guarded in this manner are available and should be generally adopted.

The crane operator should never allow chains, slings, cables, or hooks to drag along the floor, and he should never start the crane carriage or trolley until all such appendages are entirely clear. Even in the short distance that the crane might travel before they leave the floor, the slings or hooks might become caught on some obstruction and cause an accident.

No one should be permitted to ride on a load or on the crane hook; and if the craneman observes a violation of this rule he should stop the crane and refuse to move it until the person who is riding is in a safe place on the floor.

In a busy foundry the craneman must be specially alert, and his attention must be given, unremittingly, to following the various operations on the floor, taking the signals from the floorman, and controlling the movements of the crane.

Before an inexperienced man is permitted to take charge of a crane, he should be thoroughly trained in the work by a careful, well-qualified craneman, who should see that he becomes familiar with the operating mechanism, and skilled in the manipulation of the various levers and controls.

A signal gong, operated by hand or foot, or electrically, should be part of the equipment of every crane, and should be rung when the crane is started, and as frequently thereafter as may be necessary. Occasionally the gong is actuated by the mechanism that moves the crane, so that the warning signal is sounded automatically and continuously so long as the crane is moving. The objection to this method is that the sound of the gong is likely to become so familiar that its value as a warning of danger will be lost and and the men will give little heed to it. Furthermore, the gong should always be treated as an *extra safeguard*, and no other safety precaution should be omitted or allowed to fall into disuse merely because the gong is used, nor should vigilance and caution be relaxed in any respect whatever.

Some person should be specially designated to transmit to the craneman the signals for moving the loads, and the craneman should disregard signals given by other men. The signalman should stand in plain view of the craneman and should take care to give all his signals clearly. A definite and unmistakable code of signals, consisting of motions of the hands and arms, should be arranged. Signals given orally are unsatisfactory and unsafe, not only because it is often difficult to distinguish them with certainty unless the foundry is quiet, but also because the sound of loud voices will always distract the attention of other men from their work. When a load is being transported some person designated for this purpose should always walk in front of it to warn workmen who are in danger of being struck, and he should also see that the load is carried high enough to clear all obstacles in its path, because the craneman, on account of his location, sometimes finds it hard to judge the height of the load correctly.

A crane that is to be repaired should be moved to one end of the runway or to some other point where it will cause the least interference with the movements of other cranes. The controllers and the main and emergency switches should be placed in the off position before starting any repair work on cranes, and the safety switches should be locked, or the fuses removed, to prevent any movement of the crane, and to avoid accidental short circuits that might result in injury to the repairmen.

Suitable warning signs should be placed on cranes that are undergoing repairs, and buffers or rail stops should be clamped to the crane rails a few yards in front of the disabled crane when others are operated on the same runway. If practicable, a suitable floor area directly underneath the disabled crane should be roped off or inclosed in some other way, to prevent accidents that might be caused by tools or other objects falling from the crane. Similar precautions should be taken when men are at work on the runways, and red flags or other warning devices should be placed at both ends of the section undergoing repairs.

Chains and Hooks. Chains and hooks should be carefully inspected at regular intervals, and they should also be annealed from time to time by competent workmen who thoroughly understand the art of annealing, and who know how to secure the results that are desired. Particular care should be taken with hooks in this respect, because a hook, when properly annealed, should gradually yield or straighten if subjected to a serious overload, and thus give warning of danger; whereas if it is not properly annealed, and therefore hard, it is likely to snap off suddenly, without warning. Chains and hooks should be inspected with care immediately after annealing, because they are then cleaner than at other times, and hence any existing defects or flaws in them may be detected with greater certainty. All chains and hooks should be numbered, and a careful record should be kept of the inspections and annealings. Hoisting chains are particularly liable to failure through fatigue or over-strain, on account of the severe treatment to which they are frequently subjected; and they should therefore be examined minutely, and link by link, to detect insecure welds and slight cracks or other defects. Chain slings should never be crossed or twisted when placed around loads, and every chain that is to be used as a sling should be made of the highest quality of wrought iron. All chains should be oiled frequently, to prevent rusting.

Forged hooks, or laminated hooks made of steel plates securely riveted together, should be used in preference to those made of cast steel. Hooks are sometimes subjected to severe abuse by workmen who try to force them into position by striking them with heavy iron bars or other implements. This is a dangerous practice, and should be strictly prohibited.

Wire-Rope Slings. Well-made wire-rope slings give better service than chain slings, because they are stronger, weight for weight, and also because deterioration is usually indicated by broken strands that are readily discoverable by an experienced and qualified inspector. Wire-rope slings are pliable, and may be adapted to almost every use. They should be kept in good condition, and to prevent rusting and unnecessary wear from friction they should be treated with oil or with a good cable lubricant prepared specially for the purpose. Wire-rope for slings used in handling molten metal or hot castings should have a soft iron-wire core, because a hemp core is quite likely to be destroyed by the heat.

Slings in General. A sling should never be allowed to rest directly against the sharp corners of a heavy flask, casting, or other similar object, but should be protected by wooden corner-pieces, or by pads of burlap or other soft material.

Every sling, whether composed of a chain or a rope, should be long enough not only to surround the load it has to support, but also to leave a considerable space between the sling and the upper surface of the load. The oblique parts of the sling, which lie above the load and join it to the hook (or to the point where the suspension first becomes vertical) should never be so flat as to make an angle of less than 45 degrees with the ground. This precaution is highly important, but it is often overlooked or neglected, because the men do not realize that the stress on the ends of a sling is greater, the flatter (or more nearly horizontal) they lie. When the ends are inclined at an angle of 45 degrees, the stress upon each of them is about 41 per cent. greater than it would be if the ends were vertical; and if the sling is so short that it barely goes around the load and has but little slack, the stress upon it may be very great indeed.

We strongly advise that all slings, when not in actual use, be kept under lock and key and placed in charge of some responsible person who knows their condition and is competent to select safe and appropriate slings for every occasion. They may be stored in the tool room or supply room, for example, and be in charge of a qualified foreman.

Hoisting Apparatus in General. Hoisting apparatus of every kind should be inspected frequently and thoroughly, and all parts that are defective in any way should be promptly repaired or replaced. The man charged with the operation of the apparatus should not attempt to make repairs or adjustments, however, unless the foundry is a small one, where this constitutes a part of his recognized duty. Under all other circumstances he should immediately report to the foreman or repairman, in order that the job may receive attention in the proper way. If the defect is serious enough to constitute a possible source of danger, the apparatus should not be operated until the necessary repairs or adjustments have been made.

Tumbling Barrels. Tumbling barrels (or "rattlers") for cleaning rough castings are of two general types, respectively known as wet and dry. There are numerous mechanical hazards in connection with both types, and with dry tumbling barrels considerable danger to health may be caused by the dust created by them unless suitable preventive measures are adopted.

There are two methods that are commonly employed for removing the dust from dry tumbling barrels. One of these consists in attaching an exhaust system directly to the machine, and the other consists in inclosing the barrel in a dust-proof compartment from which the dust may be exhausted. The first method, as a rule, is practicable only in connection with tumbling barrels that are of special design, and are provided with the necessary attachments for connecting with exhaust fans. In nearly all other cases dust-proof inclosures must be built, and it is practicable to secure satisfactory results in this way when the system is properly arranged. The compartments should be made as tight as possible, and should be constructed of sheet metal or well-seasoned lumber. The doors may be arranged to fold, or to slide upward or sidewise; or they may be hinged to open in any way that is most convenient. In some cases rolling steel shutters are used. Doors that rise vertically should be suitably counterweighted so that they will not drop upon the workmen, and the counterweights should be inclosed. In addition to the counterweights we recommend the use of catches or fastenings for holding up the doors.

When tumbling barrels (either wet or dry) are not located in compartments, substantial double railings, at least 42 inches high, should be placed about them, with a clearance of not less than 15 inches nor more than 20 inches. (When railings are placed more than 20 inches away, workmen are likely to crawl inside of them to do any necessary work, and they are then in greater danger than they would be in if no railings were present; whereas if railings are omitted altogether, the workmen are likely to be struck or to have their clothing caught by small objects that may work through perforated or loosely-fitting covers, or by the projecting cover-fastenings.) The railings should be provided with gates so arranged that opening the gates will automatically throw the driving belts or clutches into the off position, and will prevent the machines from being started until the gates are closed. Driving belts should be guarded to a height of at least 6 feet above the floor, and all exposed gears should be completely inclosed. Chain hoists should be provided for lifting heavy covers, and suitable brakes or locking devices should be installed to prevent any movement of the machines while they are being loaded or unloaded. Securing the barrels in position by means of bars or props is a mere makeshift method, and is manifestly unsafe.

Sand Mixers and Sifters. Sand mixers are of two general types, one of which simply mixes the materials, while the other not only mixes but also grinds them. The mixer consists of a horizontal semi-cylindrical vessel in which the sand is placed and the mixing is done by revolving blades. The top of the cylinder should be covered by a substantial grating composed of $\frac{3}{8}$-inch round stock suitably reinforced to insure rigidity, and provided with free-swinging discharging doors. All gears should be inclosed by substantial guards, and the driving belt should be protected to a height of at least 6 feet above the floor. A well-designed belt-shifter should be provided, and should be so arranged that it may be locked to prevent creeping of the belt.

The combination mixer and grinder is similar to the revolving dry-pan used in the manufacture of bricks, and it may be driven either from underneath or from overhead. In either case the driving gears and all other exposed gears should be suitably inclosed, and the driving belt should be protected and be fitted with a belt-shifter, as described above in connection with the sand mixer. The revolving pan should be completely surrounded by a substantial guard of heavy, reinforced wire netting extending to a height well above the hubs of the grinding wheels. An opening should be left in one side of the guard, and at this point a sheet-metal feeding hopper should be securely riveted on.

A drag or other suitable mechanical device should be provided to force the sand out through the discharging door, and the use of hand shovels for removing the sand from the pan while it is in motion should be prohibited.

Pipe or angle-iron railings 42 inches high should be installed at the sides of rotating sand sifters, at a distance of at least 15 inches, and not more than 20 inches, from them. Belt-shifters should be provided, and the belts should be guarded to a height of at least 6 feet above the floor.

When sand mixers and sifters are driven by electric motors every precaution should be taken to prevent electric shocks and burns. See that all live wires and other parts are thoroughly insulated, and guard all dangerous rotating parts. Inclosed switches should be used, and they should be located in convenient and easily accessible positions; fuses of the inclosed type should also be used.

Automatic Molding Machines. The gears on both sides of these machines should be entirely inclosed by substantial guards of sheet metal, expanded metal, or close-mesh woven wire. The connecting rods should be similarly guarded, the inclosures in the latter case to extend as high as possible without interfering with the adjustment. Whether the machines are driven by belts or by electric motors, such precautions should be taken with regard to belt-shifters, belt-guards, and electrical safeguards as have been recommended above in connection with sand mixers.

Chipping Department. Many serious eye injuries occur in the chipping department, and practically all of these may be prevented by requiring the general use of suitably-designed eye-protectors or goggles.

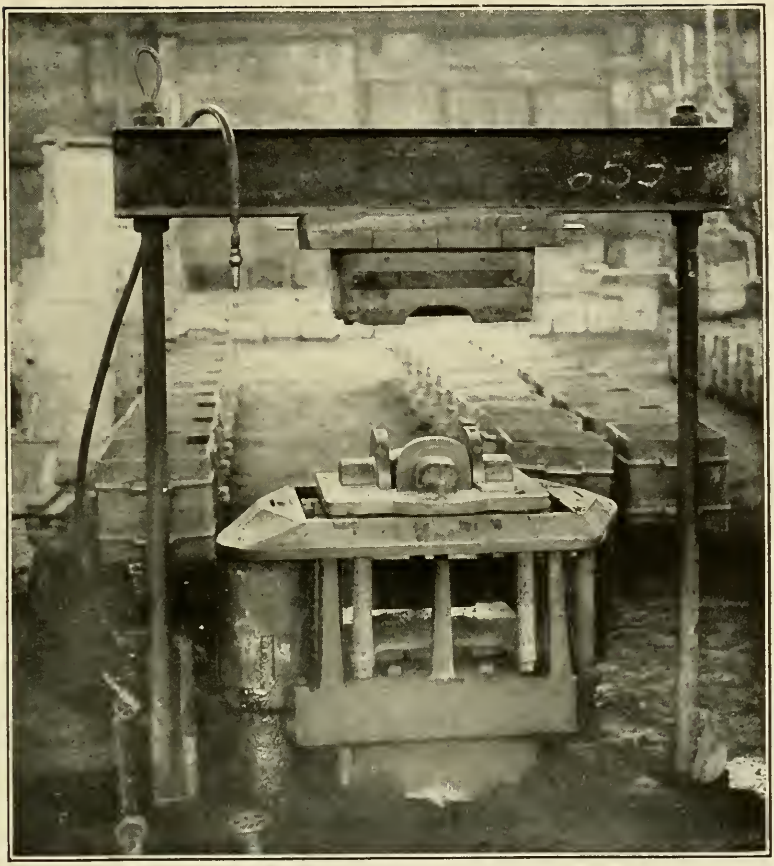

Fig. 14. Molding Machine Operated by Compressed Air.

Eye-protectors for cupola men and others engaged in handling molten metal have been described in a previous paragraph, and those to be used by chippers should be similar. Cheap, flimsy eye-protectors should not be used. It is economy to buy substantial goggles at a higher price, not only because they afford better protection, but also because they are more durable.

In addition to the eye-protectors, shields of canvas or other suitable material, mounted on substantial frames, should be provided, wherever needed, to protect near-by workmen from flying chips.

Chippers should not be permitted to work with battered or otherwise defective tools. Broken hammers and sledges should be discarded, and cold-chisels and other implements should be dressed when they become burred or mushroomed.

Grinding Wheels. Emery wheels and wheels of other abrasive materials are used in grinding castings, and these sometimes burst and cause serious injuries to the operators. All grinding wheels should be fitted with safety collars or flanges, and, where practicable, should be inclosed by substantial metal hoods connected to exhaust fans for removing the dust. Stationary grinding machines should be mounted on solid foundations to prevent vibration, and their bearings should be ample in size and be kept well lubricated and properly adjusted. It is important that grinders wear goggles, to protect their eyes from flying dust and sparks.

Further details with regard to the design, care, and operation of grinding wheels will be found in a booklet, entitled "*Grinding Wheels*", published by the Engineering and Inspection Division of THE TRAVELERS INSURANCE COMPANY.

Compressed Air. Compressed air is commonly used in foundries for operating air hoists, blow guns, spraying devices, pneumatic hammers and chisels, sand-blasts, molding machines, and sand-blast tumbling barrels. Serious accidents are often the result of the improper use of compressed air, and workmen should never be allowed to play pranks with it, but should use it only for the purposes for which it is provided. In particular, a sand-blast should never be turned upon a person, because it might easily destroy his eyesight or cause other serious injuries.

The introduction of compressed air into the human body causes great distention of the intestines, accompanied by agonizing pain; and the victim usually dies after a short period of intense suffering. Every man about the foundry should therefore make it his special business to see that no attempt is made to use the air lines for perpetrating so-called "practical jokes".

Sand-blasting. Sand-blasting may be done in the open air if eye-protectors and respirators are worn and other suitable precautions are taken, but it is far better to provide a dust-proof chamber for this work. The operator of the sand-blast should then wear an appropriate helmet, to effectively protect his lungs and eyes from the dust. The form of apparatus used should be adapted to the work to be done, and to the conditions that must be met. Considered from the point of view of the dust hazard alone, the ideal arrangement appears to consist in a helmet well ventilated by means of a hose supplying an adequate flow of dust-free air. The hose may be run from the compressed-air tank to the upper part of the helmet, and it should be provided with a regulating valve located where it may be easily controlled by the man who is to be supplied. The air current should be so adjusted that it will not only afford sufficient oxygen to serve for respiration, but also prevent dust from rising into the helmet through openings in the lower part of it. In practice, however, it is frequently found that the plan

FIG. 15. A SPECIAL CHAMBER FOR SAND-BLASTING.

(Strong air suction, through the exhaust hoods shown in the upper part of the picture, will remove a large quantity of the dust that is created, but it would be better if the ducts were placed in the floor, with gratings over them, or in the side walls. The helmet which the operator is wearing is of a type commonly used in work of this kind. As explained in the text, no entirely satisfactory helmet has yet been devised.)

Courtesy of the Western Electric News.

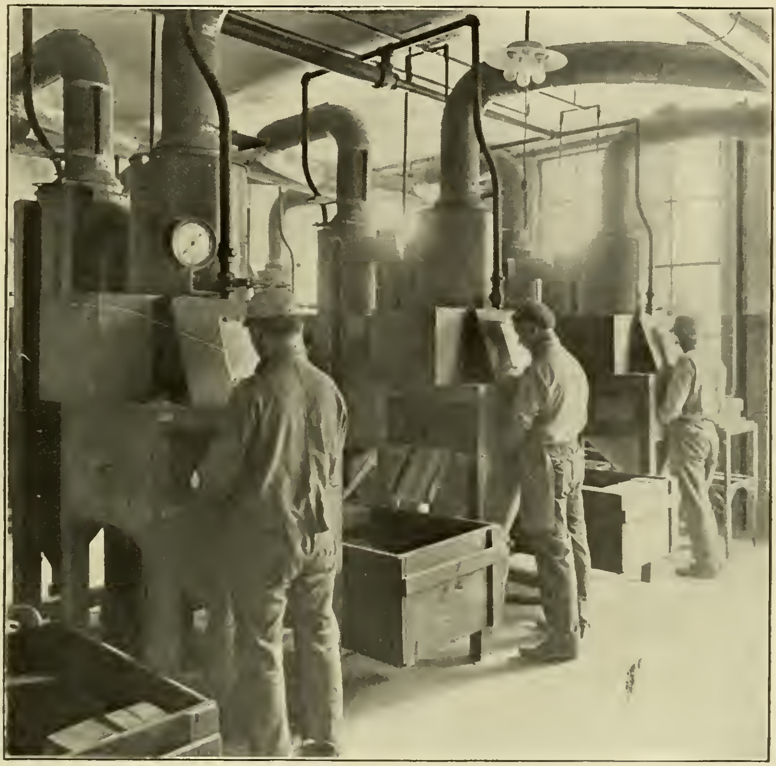

FIG. 16. CABINETS FOR SAND-BLASTING SMALL CASTINGS.

(The castings are placed in the cabinets and are held and turned about by the operators, who watch the progress of the work through glass panels. The dust is carried off through the exhaust ducts.)

here outlined is highly objectionable to the men, and in fact they often refuse to wear apparatus of this type, claiming that the cool air passing down the neck soon causes them to catch cold. Baffles and various other distributing devices to regulate the flow of the air within the helmet have been tried, but no ideal and wholly satisfactory solution of the difficulty has yet been worked out, so far as we are aware. In the opinion of certain foundry experts, an ordinary helmet with a respirator attached, or used in conjunction with a separate respirator, constitutes the best device for the protection of the sand-blaster, when all phases of the problem are considered.

Each compartment used for sand-blasting should be provided with an exhaust system capable of removing the dust in a satisfactory manner.

Illumination. The average foundry is poorly lighted, and many accidents may be attributed directly to this condition. There are many problems to be considered in providing proper and adequate light for foundries, and as the conditions that have to be met vary a great deal, it is impossible to make any general recommendations that will be applicable in all cases.

The floors, walls, supporting columns, ceilings, and materials in foundries are usually covered with grime and dust which absorb from 95 to 98 per cent. of the light that strikes them, and which give them all the same general tone or color. With no contrasting background it becomes exceedingly difficult, at times, to distinguish objects lying upon the floor, and care should therefore be taken to see that the floor is kept free from tools, materials, and obstacles of every other kind, over which the workmen might stumble. Moreover, if the ventilating system is inadequate to keep the air reasonably clear, the dust, smoke, and gases will not only reduce the intensity of the illumination and thereby invite accidents, but may also affect the health of the working force.

During certain stages of the work,—notably at pouring time,—the men are exposed to a dazzling, blinding radiation from the white-hot, molten metal. Very often, too, lighting units of intense intrinsic brilliance and high candle-power are placed where they shine directly into the eyes of the men. Conditions such as these impair the vision of the worker, thereby reducing his efficiency as a producer, and multiplying the opportunities for accidents.

One of the best artificial lighting sources for foundry work is the Mazda C lamp (500 to 1,000 watt sizes). To determine the proper location of the lamps, and their spacing, suspension heights, and other features (such as the types of reflectors that should be used) it is necessary to understand, as fully as possible, the exact conditions that must be met. Where incandescent lighting units are to be used, wall brackets, fitted with angle reflectors, provide the best means of securing satisfactory illumination at the floor level. Good results may be obtained by installing the brackets on the supporting columns, under the crane runway and below the smoky zone.

Although we have spoken only of artificial light for foundries, it is important to admit the greatest possible amount of natural light. As a usual thing, skylights are of little value on account of the clouds of smoke that often fill the upper part of the building, and therefore practically all the natural light that can be really serviceable must pass through windows in the side walls. For the same reason the effective window area must be considered as only that below a height of approximately twelve feet. It is essential that the windows occupy as much of the wall space as possible, and, where the width of the room is great, prism glass should be used. Prism glass, *Courtesy of the American Blower Company.*

FIG. 17. GOOD DAYLIGHT CONDITIONS IN A FOUNDRY.

(Observe also the ventilating duct, near the roof, and the downwardly-projecting Y-shaped nozzles connected to it through which the smoke and dust are drawn out of the building.)

when properly set, will reflect the light into the room in a nearly horizontal direction. Satisfactory natural illumination can hardly be had without keeping the windows clean; and we also strongly advise whitewashing the walls, ceilings, and supporting columns, applying fresh coats whenever they are needed.

The Foundry Yard. The fact that orderliness and system promote safety is probably nowhere better exemplified than in a large foundry yard. The maintenance and cost of a foundry yard is small as compared with that of the foundry itself, and it is good economy, therefore, to use the yard as much as practicable for the storing of scrap, sand, flasks, finished product, raw materials, and miscellaneous supplies; but the maximum efficiency and economy cannot be realized unless the yard is kept in a neat and orderly condition. If a yard is just large enough to meet the needs of a foundry, and is not used to its full capacity, it usually follows that the foundry floor-space is littered with material that could be stored in the yard more advantageously; and the crowding of the foundry floor increases the number of accidents, many of which might be eliminated if the yard were utilized to better advantage. This is specially true of a foundry where every available foot of floor space is required for production. In this class belongs the "jobbing foundry," in which work of a miscellaneous nature is done, as distinguished from the "repetition foundry," in which the work consists mainly in the continuous reproduction of certain standard stock patterns.

The jobbing foundry owes its existence to the fact that many manufacturers who use castings have no room for a foundry, or have too limited a need for castings to warrant the expense of maintaining a foundry of their own. A foundryman who depends largely or wholly upon job contracts to keep his plant in operation usually has to turn out an exceedingly varied assortment of castings, and speed is often an essential factor in the contract. This means that as soon as one job is finished, the flasks and patterns must be removed and a different set substituted. If the yard is not well kept there is little likelihood that there will be ample space in it for the flasks and sand, and if there is not, it may be necessary to use the foundry floor for storage until the new flasks are brought in. The floor is then in a disorderly, crowded state, just when clear space is needed. It is evident that the probability of accident is greatly increased when such conditions prevail.

It is important for the foundry yard to be level and fairly smooth, and it will pay the owner well to put forth every reasonable effort to secure a yard of this kind. Material can be handled and stored with much greater safety and facility, in a level yard, than in one that is sloping or uneven. Foot paths, and passageways for wheelbarrows and trucks, can also be kept in good condition more easily.

A considerable part of the space in a yard, particularly when it belongs to a jobbing foundry, is devoted to the storage of flasks. The flasks should be carefully piled, so that they will not fall over, and they should also be arranged in an orderly manner, according to size, type, or combinations. Attention to these details will no doubt consume more time than would be required to store the flasks promiscuously; but the extra time is well worth taking, on account of the ease with which the flasks can be located, and the safety with which they can be withdrawn when they are again needed in the foundry,— to say nothing of the greater safety that proper storing insures, during the intervening period. If the flasks are heaped up in disorderly piles, or stored in other indiscriminate ways, accidents are likely to happen when the workmen are endeavoring to extricate one that is more or less buried or hidden. If the particular flask required cannot be located readily, a less desirable one is used, or a makeshift is hastily constructed. In the foundry these misfit flasks often cause

Courtesy of the General Electric Company.

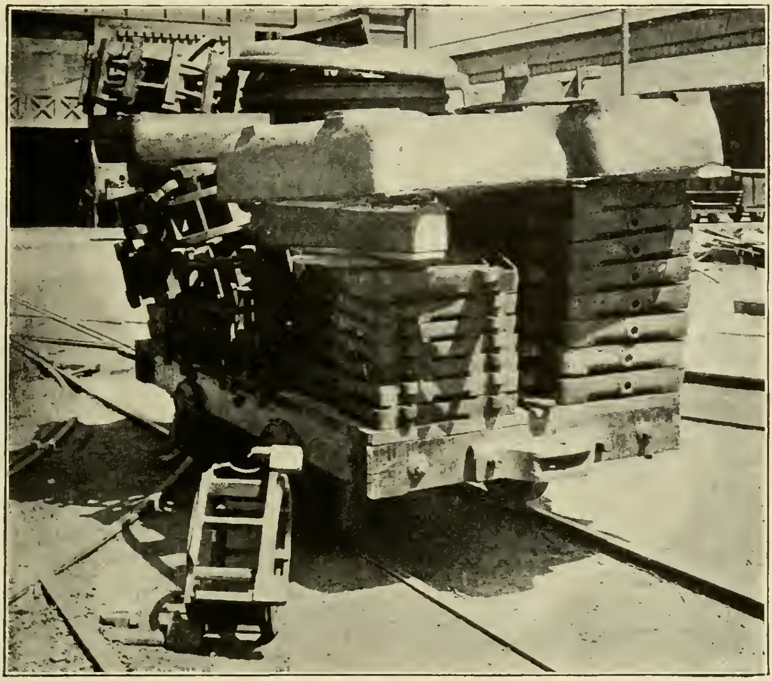

FIG. 18. DANGEROUS LOADING OF A CAR USED FOR TRANSPORTING FOUNDRY MATERIAL.

burns, many of which could be avoided if more system were used in storing the flasks in the yard, so that the right one could be found without delay.

When materials or equipment are stored or piled by the side of car tracks, a clear space of not less than six feet should be maintained between the tracks and the piles. Workmen engaged in the movement of cars, or other employees who are obliged to use the car tracks in the performance of their work, are likely to be caught and killed, or severely injured, unless ample clearance is provided.

At all places where railroad tracks cross roadways, runways, or footways, planks should be nailed down between the rails and at both sides of them, or other equivalent measures should be taken, to provide a smooth passageway over the rails for wagons, trucks, or barrows, as well as for foot passers. This greatly facilitates the crossing of the tracks, and it also reduces, in large measure, the shocks to which loads would otherwise be subjected, and the consequent danger of material falling off and injuring the men. The planks (or their equivalent) should be *flush* with the rails, however, and they should come snugly up to the rails on the outside, and as close to them, on the inside, as the flanges of the car wheels will permit. Warning signs should be posted at all crossings, and the men engaged in car movements should always blow a whistle or sound a gong or bell as the cars approach a crossing.

Whenever tracks or roadways are depressed, they should be guarded by substantial railings. Furnace pits and excavations of all kinds should also have effective protection of the same nature.

All manholes should be kept covered with wooden tops, or with covers made safe by the use of non-slip material or by being checkered with a raised pattern; and the covers should be set as nearly flush with the surrounding surfaces as possible. Many serious injuries have resulted from workmen slipping on smooth, wet manhole covers of iron or steel, and from tripping over covers projecting above the level of the floor or the ground. When it is necessary to remove a cover, a guard rail should be placed about the hole immediately, and a danger signal secured to the guard rail.

Sand bins and coke bins, particularly those constructed of wood, often get badly out of repair. The boards become warped and bulge out under the weight of their contents, and they often split or crack in such a way as to present dagger-like points, or slivers, that are likely to catch the unwary workman, especially at night or during late afternoons in winter months, when the light is poor.

Good, serviceable walks should be provided throughout the yard. If the walks are conveniently located and are kept in good order, the workmen will use them; but if these conditions are not fulfilled, the men will climb over scrap piles or under cars, in order to "make a short cut." Cinder paths are no doubt the most serviceable for foundry yards. Loosely-laid boards are continually getting out of place, and they are also likely to become warped so that they will not lie flat. Boards often warp enough to split, even when they are nailed down; and in such cases they may constitute a more or less dangerous tripping hazard to the workmen.

The safest way to store pig iron is to stow it in bins, or pile it up in neat stacks. This is more costly, however, than throwing it down promiscuously in piles, and hence the safer methods are often neglected. Electromagnetic cranes are coming into wide use for handling pig iron, and although they are very convenient, they have serious drawbacks when regarded from the safety standpoint, and their hazards should be clearly understood and carefully avoided. When the electromagnet is used no one should be permitted to stand, walk, or work near the path followed by the magnet, because any interruption of the electric service, from the opening of a switch, the blowing of a fuse, the short-circuiting of the magnet coil, or any other cause, will instantly let the whole load drop. Sometimes, too, a pig is barely held by the magnet, so that the least jar will break its contact and allow it to fall.

Safety, neatness, and convenience may be secured by constructing stout bins and dividing them into compartments, preferably of one-car capacity each, in which the pig iron can be deposited by the magnet crane,—always provided the dangers incident to the use of the magnet are borne in mind and avoided. When the iron is piled high in loose, irregular heaps, there is danger of one or more of the pigs becoming free and tumbling down upon workmen. This hazard is avoided when substantial bins are employed.

In many foundry yards boxes and barrels are used to store worn-out tools, small scrap material, discarded lumber, and other rubbish. It will materially assist in keeping the yard in a neat, safe condition, if the barrels or boxes used for this purpose are kept in convenient places, because the men are then more likely to make use of them. It is important, too, to keep all such receptacles in good order. It is not uncommon to see the ragged edge of a worn-out shovel blade, or some other discarded tool, sticking out menacingly over the edge of a box or barrel. Heaping up the scrap so that it stands high above the receptacles, or allowing it to project over the edges of them as just described, should be prohibited, because careless habits of this kind increase the dangers about the yard and invite injury, especially at night.

Barrel hoops are frequently left lying about, and when a workman steps on such a hoop it is likely to swing up and strike him smartly, often causing acute pain, or perhaps producing an actual abrasion or lesion, if it contains a sharp nail. This particular hazard may be taken as representative of a large class of others that are seemingly trivial in nature, but which are well worthy of attention in the aggregate. These minor accidents are often attended by grave consequences, not only because they may be followed by septic poisoning, but also because they frequently occur when the workman is engaged at some important task involving the safety of himself or others. Coming at such a time they take him by surprise, and they are likely to make his attention lapse momentarily from the work in hand,—perhaps with disastrous results. A book might be written about the big consequences of little things.

When old castings and other metal objects are broken up the work should preferably be done in the yard. A "skull-cracker" or "yard-drop" is usually employed for breaking these objects, and this consists of a derrick or hoist which lifts a heavy metal ball and drops it on the castings. Pieces of the objects are likely to fly in all directions when the weight falls on and breaks them, and all persons in the immediate vicinity are endangered by these pieces. Every skull-cracker should therefore be entirely surrounded by a substantially constructed fence, barricade, or inclosure, of sufficient height to protect persons working in the vicinity, and all passers-by, from injury from flying fragments of metal. In addition, a suitable shelter-house should be provided for the operator of the skull-cracker and his helpers, and all these persons should go into the shelter-house *before the ball is raised.* A safety drop-hook should be used to prevent premature or accidental dropping of the ball, if the weight is held by mechanical means; and if an electro-magnet is employed to raise and hold the weight, the utmost care should be taken to keep the electrical circuits and devices in perfect condition. All gears, sprockets, and other dangerous moving parts of the skull-cracker should be covered or otherwise rendered harmless by the installation of standard guards.

INDEX