Fuel Handling, Storing and Firing

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1. Every year, many workers are injured and much property is destroyed as a result of fire and explosions due to handling, storing or firing of fuel. The severity of the injuries and the cost of these accidents make it especially necessary for management to consider preventive measures. There are many methods and kinds of equipment for handling, storing, and firing fuel, but no attempt is made in this pamphlet to discuss their comparative efficiency. On the other hand an effort is made to point out the fire, explosion, and personal injury hazards ordinarily encountered in this work and to suggest means of controlling the hazards involved.

2. The principal fuels used for steam production are:

a) Coal (ordinary sizes).
b) Pulverized coal.
c) Fuel oil.
d) Gas.
e) Wood refuse.

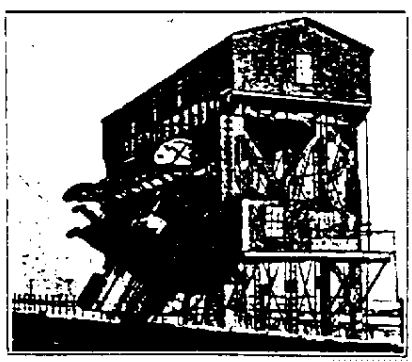
Coal

Unloading at Plant

3. Coal is brought to most plants in railroad cars which are switched off the main line onto the plant side track. Usually side tracks are protected by switches that are locked with padlocks, the keys being in the possession of railroad men only. After a car is "spotted" (placed for loading or unloading) the hand brakes should be set and the wheels blocked, and a blue metal flag during the day and a blue light at night (standardized railroad equipment) should be placed between the rails at each end of the car or string of cars and kept there during the time that men are actually at work, to give warning that the car or cars should not be moved. Wherever possible, cars should not be loaded or unloaded on a grade. If this cannot be avoided the cars should be held in place by car blockers. When moving a car by hand, it is advisable to use a car mover, not an ordinary crow bar. Every effort should be made to maintain a clearance of at least 8½ feet from center of the rails to the nearest pile of material, building, or other object. Where such clearances do not exist, some companies post warning signs which read "No clearance." Rope telltales should be installed at each side of places where the overhead clearance is not great enough to allow men to stand on top of cars. Men should be warned not to walk alongside moving coal cars because of the danger of falling lumps. (See Figure 2.)

This pamphlet is one of more than 150 Safe Practices and Health Practices Pamphlets. It is a compilation of experience in accident prevention from many sources. It should not be assumed, however, that it includes every acceptable procedure in the field covered. It must not be confused with American Standard safety codes; federal laws; insurance requirements; state laws, rules, and regulations; and municipal ordinances. *Additional copies of this pamphlet are available. Member price, 35 cents each. Quantity and non-*

4. If the cars are run onto a trestle, it is advisable to install safe footwalks on both sides of the trestle, connected at intervals by crosswalks. The footwalks should be protected on the outside by double handrails 3½ feet high and by 6-inch toeboards; they should be wide enough to permit the safe and easy operation of car wrenches described in paragraph 6. Crosswalks and the inside of the footwalks in some plants are guarded by stringing wire cables across the openings so as to catch any person stepping or falling from the walk. If cars are moved at night, close side clearances, as well as low points of overhead clearance, should be well lighted. Telltales should also be installed.



Courtesy Youngstown Sheet & Tube Co.
Figure 1. Car dumper in operation. (See paragraph 9.)

5. When coal is unloaded from cars into a hopper where men might walk or fall into the bin below, it is advisable to place a grating over the hopper. One company has installed a series of chains across the top of each coal hopper; one end of each chain is secured rigidly in position, the other end is attached by a heavy spring. Another company uses a heavy grating of bars about 12 inches apart. Such installations permit large lumps of coal to pass through but would hold a man who otherwise might fall into the hopper. (See Figure 3.)

Unloading hopper cars

6. Most plants receive coal shipments in cars of the hopper type which are opened by placing a special wrench on the square end of the chain shaft and turning it to release the chains. When the hopper doors start, they sometimes open with a rush. If an ordinary wrench is used it may be torn from the operator's hands and the man injured or killed. Large safety wrenches are much better for this work, although even then it may be necessary to bend or offset the handle so it will not pinch the operator's hands against the side of the car. The usual safety wrench is constructed with a hinged jaw that releases when the door shaft starts to revolve. This prevents the wrench from being thrown violently against the operator.

Another feature is the safety disc which prevents the man's fingers from becoming crushed between the wrench handle

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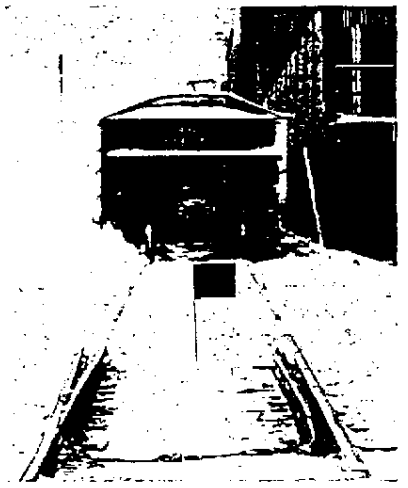


Courtesy Youngstown Sheet & Tube Co.
Figure 2. Car spotted with blue warning flag placed. (See paragraph 3.)

and the car or ground. The end of the handle is bent at 90 degrees for about 4 inches to prevent the use of pipe as extensions. (See Figure 4.) Industrial Data Sheet No. D-RR5 gives further information about opening and closing freight car doors.

7. It is sometimes necessary for a workman to get into a car and loosen the coal that may be frozen or jammed to make it fall through the hopper. If this is done there is danger that when the coal starts to move the man may go through the hopper, too. To prevent this, any man entering a car with the hopper open or about to be opened should wear a life belt with the attached rope securely fastened to the top of the car or other fixed object, as illustrated in Figure 5. A second man should attend this rope to render assistance if needed. Some plants have thaw houses into which the coal cars are run in the winter time. The frozen coal is there thawed out to insure its easy and comparatively safe unloading.

8. In some western states, hopper cars used for the shipment of coal and ore are constructed differently from those ordinarily met with in the East. On some of the western roads, the hopper cars are dumped from the end of the car by means of four shafts, two at each end of the car, which run close to the edge of the car from the center to the end. There are several types of ratchet mechanisms used on these cars, and the operation of them is hazardous enough to warrant consideration in this pamphlet.

a) One type consists of a mechanism in which the ratchet is rotated by placing a pole in the socket provided for that purpose. The ratchet is controlled by a movable pawl which has a safety tip at one end to prevent the pawl from slipping over and engaging the ratchet on the opposite side. Occasionally, when these cars are being loaded, the safety tip becomes engaged with the ratchet making it necessary to cut the tip off. When this is done, the pawl is free to slip from one side to the other and engage the ratchet. This introduces the hazard of the entire mechanism, including the pole, rotating when the car bottom drops and the ratchet starts to rotate. When this occurs, the pole is thrown around like a flail. Men should make certain that the safety tip is in place on this type of ratchet mechanism before starting to unload. If the tip is missing, then another worker should be present to hold the pawl into the ratchet in the proper position so that it cannot slip over. (See Figure 6.)

b) In another type of mechanism, similar to the one described in "a," there is no safety feature on the dog, so it is always possible for it to slip over into the opposite position. In unloading these cars, a safe method devised by one Council member is as follows: The pole is placed in the socket in the regular manner, but it is made long enough that it extends all the way through the socket toward the draw bar. Then the worker, instead of lifting up on the pole in the normal operating position, pounds on the lower end with a sledge hammer. This causes the ratchet to rotate, and even if the dog should slip over, the worker is out of line of the path of travel of the pole. It also eliminates the severe effort necessary to start the ratchet by lifting. It is said that hernias, which were quite frequent before this method was put into use, have now disappeared from this company's plant. (See Figure 7.)

c) The third type is a mechanism which has a permanent handle attached. On this handle, the dog which engages the ratchet is free to revolve from one side to the other, thus making it possible for it to slip over at any time in the opposite direction. The method devised for unloading cars of this type is to tie the dog loosely with a heavy cord so that it cannot revolve into the other position. In dumping, a bar is placed under the lever with one end on the car step. The operator lifts under the lever with this bar and thus gains greater leverage for the lifting operation, and at the same time keeps himself out of the line of travel of the handle.

Unloading gondola cars

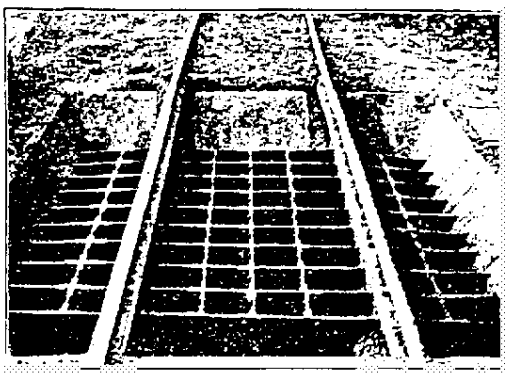
9. If the coal is delivered in ordinary gondola cars without hoppers, it is necessary to unload the coal either by hand, by a grab bucket, or by a car dumper that raises and turns the entire car and dumps out the coal. (See Figure 1.) With such a device either a mechanical or an electrical method for signalling between the chief car worker and the dump operator should be arranged. If possible, the controls should be elevated or so situated that the operator has a good view of the car to be raised; this will minimize the danger of operating the hoist when anyone is on the car or in any other position where he may be injured. A safe and convenient means should be provided for getting into and out of the dumper.

10. In unloading coal with grab-buckets, severe injuries have occurred where helpers have been caught between the bucket and the side of the car. It is best not to permit too many men to enter a car—preferably not more than one at a time. Even then it requires careful cooperation between the bucket operator and the man in the car if accidents are to be prevented. It should be an inviolable rule that the bucket is never to be moved unless the trimmer is at the farthest possible point, in the car, from the bucket.

11. If men are shoveling out the coal by hand they should be at least 6 feet apart; otherwise they are apt to get in each other's way or be injured by being hit with a shovel.

Unloading coal from river barges

12. Many plants receive their coal in river barges which are unloaded by



Courtesy "Work Accidents and the Law," by Crystal Eastman
Figure 3. Grating over coal hopper. (See paragraph 5.)

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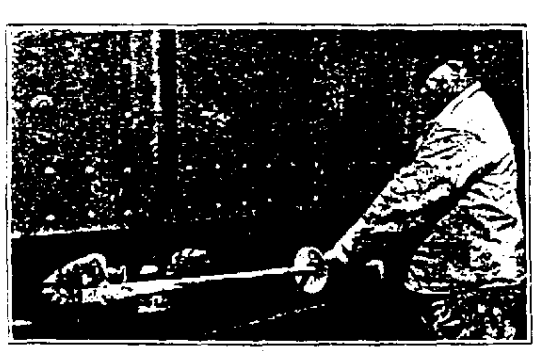
grab buckets. In such plants, besides arranging a good signalling system, it is necessary to provide one or more small sized life preservers with a tow rope and self-igniting water light attached. These should be placed in weather-proof, plainly marked cabinets where they will be available at all times and the free end of the rope should be looped over the storage box stanchion. Where the barge is more than five or six feet lower than the dock level, a life preserver should be placed on the barge while it is being unloaded. Valuable time might be lost while a barge man climbed up on the dock for the life preserver.

13. Trimmers should be instructed never to stand under the bucket at any time. Serious head injuries have resulted by men being struck with falling lumps of coal and other cases have been reported where men were crushed by the descending bucket.

14. Men working as trimmers on gondola cars or barges that are unloaded by cranes or working around moving cars should be compelled to wear safety hats. Supervisors, inspectors or other persons who may be exposed, even for a few moments, should also be compelled to wear this type of head protection.

15. After it is unloaded, coal may be moved by hand shoveling, wheelbarrows, carts, trucks, cars, screw or spiral conveyors, belt conveyors, flight or scraper conveyors, bucket conveyors and elevators, apron conveyors, portable conveyors, reciprocating plates, locomotive cranes, overhead traveling cranes, gantry cranes, monorail cranes, hoists and trolleys, or by electric larries.

16. When men are shoveling coal by hand the shovel handles should be kept in good repair, the shovel lip should be straight across and comparatively sharp —not curled up; the men should not work so near together that there is danger of their hitting each other, and no shovel should be left lying about the floor to trip or cut anyone passing by. (Safe Practices Pamphlet No. 41 discusses the safe use of shovels, also other points on the general subject of "Hand Tools.")



Courtesy Aetna Life Insurance Co.

Figure 4. Safety car wrench in use. (See paragraph 6.)

17. Many of the accidents which occur in the hand operation of carts, wheelbarrows, small cars, and trucks can be eliminated by the provision of suitable equipment, by proper maintenance, and the exercise of care on the part of the workers. Important details concerning the prevention of such accidents are discussed in Safe Practices Pamphlet No. 54, "Handling Material (Hand and Truck)."

Conveyors

18. The principal danger in operating screw or spiral conveyors is that of a man getting his hands or feet caught in the conveyor. All screw conveyors should be covered, preferably with a solid enclosure. Sometimes a second cover made of heavy wire mesh is placed underneath the solid top. Both sets of covers should be made in removable sections so that when any number of top sections are removed for the purpose of making an inspection or locating a choke-up, the mesh cover still provides protection against injury; and when the choke-up is in place, only the sections of the mesh cover at the choke-up need be raised. Under no circumstances should an effort be made to loosen material that has caused a choke-up, nor should any repair work be attempted while the conveyor is in operation. The power should invariably be shut off first. Particular care should be taken to guard the openings in screw conveyors at charging doors and to enclose all driving gears, belts, and pulleys. Screw and other types of conveyors mentioned in this pamphlet are described, and the prevention of accidents resulting from their use is discussed in detail in Safe Practices Pamphlet No. 35, "Conveyors." Before making repairs on any coal handling or other power plant apparatus, care should be taken to open and lock all control switches or close and lock valves on steam driven equipment. A warning tag should be fastened to the switch or valve indicating that men are working on the apparatus.

Courtesy Ford Motor Company

Figure 5. Every man entering a coal bin or a car of the hopper type should wear a life belt and life line. (See paragraph 7.)

19. The safety features of belt conveyors include the use of loading hoppers, low tension in belt, reasonable speed of operation, sweep guards to prevent workmen from riding on the belt, enclosure of driving mechanism, guards at sides of belt to prevent men from crossing over except at steps and walks specially provided for that purpose, and safe method for operating conveyor tripper. In some plants, an emergency cord or wire extends the full length of each side of the conveyor. Touching this wire at any point along the conveyor route will stop the conveyor. If a belt conveyor operates over a passageway or workplace, a screen or solid guard should be installed underneath to prevent workmen from being injured by lumps of coal which may drop from the conveyor.

20. Flight conveyors, bucket conveyors and elevators, and apron conveyors are merely adaptations of the chain type of conveyor which operates over a sprocket wheel at each end of the run as described in Safe Practices Pamphlet No. 35. These conveyors should be guarded at the sides—particularly if they operate on rollers—

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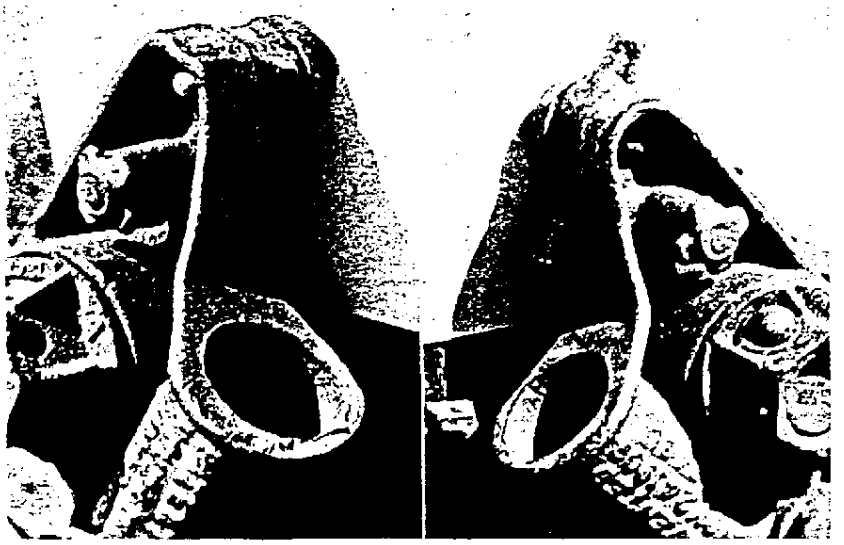

Figure 6. Ratchet pawl with and without safety tip. (See paragraph 8 a.)

and underneath where they run over passageways and workplaces. Solid guards at least 6 feet high (preferably extending as high as the machinery itself) should surround all vertical bucket conveyors and elevators. These guards will prevent anything from being dropped or pushed into the shaftway, and will also hold within the shaftway any material that may drop from the buckets. Windows with wire glass, or doors, or removable sections should be provided in the enclosures to facilitate inspection, cleaning out, and repairs of the conveyor. Bucket elevators or inclined conveyors should have safety stops to prevent the machinery from running backward in case the power is shut off. In some plants, stopping buttons are provided at a number of places along each conveyor so that an operator can quickly shut off the power in an emergency. Where two or more conveyors are operated together and one conveyor feeds coal to another, the controlling devices should be so interlocked that in starting up, the farthest conveyor will automatically be started first and in stopping, both will stop simultaneously.

Portable conveyors

21. Conveyors are also made in portable, electric - motor - driven units which present the same hazards that are encountered in stationary conveyors. All gears, chains and sprockets should be completely enclosed in guards constructed of No. 12 gage sheet metal securely fastened to angle iron supports. All live electrical parts should be enclosed, and armored cable should be used to connect to the power supply. Motors should be electrically grounded. (Electrical hazards are discussed in Safe Practices Pamphlet No. 29, "Electric Equipment in Industrial Plants.")

22. Reciprocating plates should have the drive gears enclosed. There should be ample clearance at both ends of the plate travel, or barrier guards should be erected, to eliminate the danger of men being caught between the traveling plate and any fixed object.

Cranes, hoists, and larries

23. Safety features for locomotive cranes should include a clearance of at least 14 inches between the bottom of the boiler and the truck frame; a fence on truck bed, which when extended will prevent anyone from being caught between boiler and bed; outriggers and rail clamps; automatic couplers; two doors in halves, one half above the other, hinged at rear, swinging outward, one such door on each side of cab; pointer indicators showing safe load at any angle of the boom; an electric indicator to warn operator when crane tilts too far; a guard at the end of the boom to prevent the cable thimble from striking the sheave wheel; a guard at the point where the boom cable passes over the idler; enclosing guards for gears, reciprocating and revolving parts; and a guard for the boiler water gage glass. (For further details see Safe Practices Pamphlets No. 33, "Hoisting Apparatus," and No. 4 "Cranes.")

24. In preventing accidents to the operators of overhead electric cranes, gantry cranes, monorail cranes, hoists and trolleys, and electric larries it is necessary to guard all electric equipment and wires, enclose all belts, pulleys, gears, chains, sprockets, shafts, and other revolving or reciprocating parts, install safe ladders or stairways to operating stations, and provide ample head room for operators—especially on monorail installations. These and other important details are discussed in Safe Practices Pamphlets Nos. 33 and 34.

Coal crushers

25. If coal crushers are used, all belts, pulleys, gears, chains and sprockets should be guarded and the crusher pits should be properly lighted and drained. If water collects on the floor, a film of coal dust will float on top of it so that workmen cannot detect pits or differences in floor level. Otherwise, serious falls may result. Metal grating over the crusher through which the coal can pass, and heavy wire mesh screens at the sides will prevent workmen from getting their arms or legs caught in the rolls. A safe and convenient method should be provided for getting in and out of the crusher pit. (See paragraph 61.)

Coal storage

26. If the coal pile does not ignite spontaneously, there is very little if any loss in heating value when coal is stored either under cover or in the open air exposed to ordinary weather conditions. The greatest trouble experienced in storing coal is that of having the coal pile burn as the result of spontaneous ignition. Anthracite coal can be stored indefinitely, but bituminous coal in storage, particularly if it has been freshly

Figure 7. Another type of mechanism for end dump cars. (See paragraph 8 b.)

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mined or freshly crushed, must be watched closely and certain precautions taken to prevent spontaneous ignition. The coal absorbs oxygen from the air, heat is developed faster than the air supply can carry it away, and the rise in temperature speeds up the oxidation of the coal. One helps the other until the temperature becomes so great that the coal will burst into flame and burn, or if the air supply is limited the pile will smolder and coke.

27. It is usually very difficult to extinguish the fire in a coal pile. Water poured onto the pile seldom reaches the burning area, for the tarry products of the burning coal form a crust over the fire that is practically waterproof. Some companies have succeeded in extinguishing such fires by using a special type of nozzle that is sharp pointed and can be thrust into the coal pile and made to penetrate the crust into the burning area. The water (or steam) issues from holes in the sides of the nozzle and may extinguish the fire. Sometimes tar clogs up the holes, so the nozzle becomes useless.

28. It is advisable, however, to use water only after other methods have failed. If excessive heat develops in a coal pile it is best to dig in and move all the coal that is thought to be heating. If the coal is ablaze it may be necessary to add water. Otherwise, the coal should be spread out and allowed to cool before it is repiled, or better still, it should be used at once.

29. Coal burning or smoldering in storage piles or in bins often generates carbon monoxide. If this poisonous gas is breathed it may cause dizziness, unconsciousness, or even death. Operators, therefore, should be careful when working around piles or bins where the coal is burning or smoldering; under such circumstances it is often necessary for them to wear devices that insure a supply of pure air. It is advisable that adequate ventilation be provided over coal bins to remove any gas or smoke that might be given off by burning coal.

Courtesy University of Illinois Engineering Experiment Station

Figure 8. The Standard Oil Company at its Whiting, Indiana, plant prevents the spontaneous ignition of its enormous bituminous coal supply by storing the coal under water. (See paragraph 30.)

30. There is only one positive method of preventing spontaneous heating of bituminous coal in storage; that is by storing the coal under water. Air is thus excluded and there is no oxygen available to unite with the coal. The objection against firing wet coal may be overcome by removing part of the coal and allowing it to drain until needed. The amount of moisture remaining in the coal would then be no greater than that often supplied by firemen who wet down the coal before feeding it into the boiler furnaces. Most coal consumers find it impracticable to store coal under water because of the high installation costs. The next few paragraphs contain suggestions that can be followed when ordinary coal storage methods are employed. (See Figure 8.)

31. It is a general rule that the smaller the pieces of coal, the more danger there is of spontaneous heating. This is because a great number of small pieces present a greater surface area to the action of the air than a few large pieces. Some companies, therefore, purchase screened coal only, or they screen all coal as soon as it is received and send the fine coal to the power plant to be burned and the lump coal to the storage pile. Care should be exercised not to break up the lumps of coal any more than is absolutely necessary when placing coal in storage. If handled in a grab bucket, do not open the bucket too high above the pile. Some grab buckets are arranged to open automatically when the bottom of the bucket is in contact with the top of the pile.

32. For a long time it was believed that the sulphur contained in the coal was responsible for spontaneous ignition in coal piles, but leading authorities now state that the chief reason why sulphur in coal is objectionable is that it causes the coal to break and crumble, thus increasing the area of coal surface exposed to the air, and therefore speeding up the development of heat. If the coal has

Courtesy University of Illinois Engineering Experiment Station

Figure 9. Coal pile with temperature tubes. (See paragraph 35.)

a high sulphur content, it is advisable to watch it closely for the first two or three months after it is placed in storage so that immediate steps can be taken to check the development of excessive heat.

33. Some authorities state that coal should be stored so that its temperature can be ascertained daily and so no pile of bituminous coal is more than 12 feet deep, nor so arranged that any point in the pile will be more than 10 feet from an air cooled surface. While it may be true that fires are more common in deep than in shallow piles, the reason is by no means certain. Arguments used by persons who advocate low piles include: if the coal is piled too deep, the air cannot carry away the heat from the interior of the pile; it is more difficult to obtain interior temperature readings; and it requires considerably more work and time to move the coal if a fire once gets started. The consumers who have the deepest coal piles, therefore, usually have the best equipment that is obtainable for digging in and removing the coal quickly in case fire is discovered.

34. Attempts have often been made to ventilate coal piles but in the majority of cases this has been unsuccessful. Open pipes and ventilating tunnels have been arranged, but usually instead of carrying away heat from the interior of the pile, they provide only a greater supply of air and assist rather than retard spontaneous ignition.

35. It is advisable, however, to arrange pipes in the coal pile at different points, not to ventilate the pile but make it easier to determine tempera-

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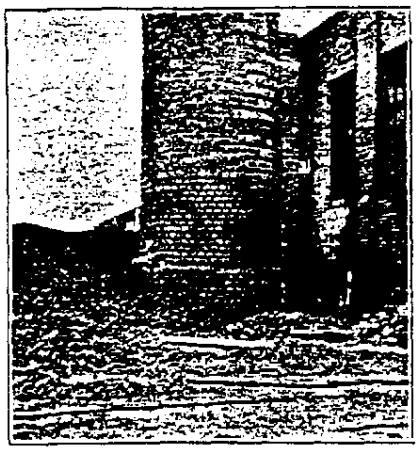


Courtesy University of Illinois Engineering Experiment Station

Figure 10. This coal pile burned because heat from the chimney encouraged spontaneous ignition. Photograph was taken after part of the pile had been removed. (See paragraph 37.)

tures. These pipes should be closed at the tops with stoppers. Thermometers can then be lowered in the pipes and readings taken at regular intervals. The stoppers prevent the pipes from acting as flues for the circulation of air, they enable the workmen to secure true thermometer readings, and prevent coal and other objects from falling into the pipes. If the temperature at any point reaches 140 degrees Fahrenheit, the pile should be carefully watched. If the temperature rises rapidly to 150 degrees or 160 degrees, the coal should be dug out and cooled or used immediately. (See Figure 9.)

36. It is quite generally believed that the repeated wetting and drying of coal increases the possibility of spontaneous ignition. This may be because the moisture causes the coal to break up into smaller pieces; whether or not this is the real reason, it is advisable to watch the coal pile carefully after each fall of rain or snow. Similarly, it is not wise to put wet coal into a pile or to pile coal on a floor that is wet or not well drained.

37. Coal should not be piled up against a boiler setting, or near steam pipes or other sources of heat, even though the amount of heat transmitted is moderate. This would encourage oxidation of the coal and might result in spontaneous ignition. (See Figure 10.)

38. Many fires have started in coal piles because the places selected were not suitable or were not properly prepared for coal storage purposes. Coal should not be piled on a wooden floor, for the wood itself is flammable; air also may leak in between the boards and promote spontaneous heating in the pile. A floor of cinders, ashes, or other refuse is equally objectionable because it is porous and may leak air. Furthermore, such refuse may contain oily rags which of themselves might start a fire by spontaneous ignition, or it might contain other flammable material such as wood, shavings, paper, etc. Concrete makes the best floor; if this is prohibitive because of the expense it is advisable to store the coal on well drained hard clay.

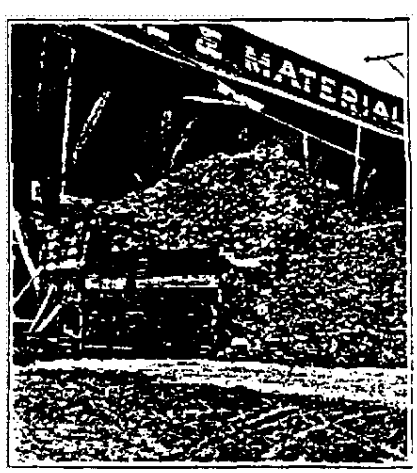
39. If a great quantity of coal is to be stored, it might be well to guard against the indefinite spread of fires by arranging a number of separate piles or by dividing the storage space into a number of bins or pockets separated by smooth walls of concrete. Care must be exercised, however, to prevent the entrance of air to the interior of the pile through passages around such objects as timbers, trestle supports, or irregular brick work. (Figure 11 illustrates a dangerous condition where coal is piled around timber trestle supports, a telegraph pole, and wooden braces for the retaining wall.)

40. Some companies store lump coal in enclosed towers and state that there is no danger of spontaneous heating if the coal is cool when stored, not freshly mined or freshly crushed, and if the towers are practically air-tight at the sides and bottom.

41. Although it is best to store lump coal only, as discussed in paragraph 31, if it is necessary to store coal without screening, it should be piled in layers in such a way that the fine coal and lumps will be distributed uniformly. Spontaneous heating is almost sure to occur where the coal is dumped on the peak of a pile already formed. Where this is done the coal will pyramid, that is, the fine coal will remain in the center at the top, and the coarse coal will roll down the slope to the outer edge of the pile. In the central section the fine coal will be densely packed so air cannot circulate to support combustion, and along the outer edge the coal is too coarse to heat. About half way up the slope, however, the spaces between the coarse coal are partially filled with fine coal and through the remaining space air can circulate just freely enough to promote combustion but not freely enough to carry off the heat. It is in this zone that the greatest heating takes place.

42. A comparatively recent development in storing coal is the packing and rolling method whereby the coal is piled in layers, each about 3 feet deep. Each layer is smoothed and packed down before another layer is added. This is often accomplished by a caterpillar tractor dragging an ordinary road drag and by mallet and hand tool tamping. The principle of this method is to pack the coal tightly to exclude the air. When finished, the coal will to a considerable extent shed water. Several members of the Council following this procedure have piled coal as high as 30 feet and have found the temperature in the interior of the pile well within safe limits.

43. In reclaiming coal, workmen should never undercut the pile or shovel out a section leaving an overhanging mass that may fall or slide down on top of them. The danger in doing this is greater if the coal is wet or frozen. Coal should always be worked down from the top of the pile. In wintertime it may be necessary even to blast the coal at certain points to break up the frozen chunks that are too large to be handled. Explosives should be used and handled only under the direct supervision of experienced men who fully understand all of the dangers associated with the work. (See Safe Practices Pamphlet No. 28, "Commercial Explosives.")



Courtesy University of Illinois Engineering Experiment Station

Figure 11. Poor coal storage. Note wood retaining wall. (See paragraph 39.)

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Coal bunkers

44. It is the practice in most plants to keep one or more days' supply of coal in bunkers from which it can be conveniently drawn for use in the boilers. It is occasionally necessary for men to enter the bunkers to break up or shovel down the coal. Fires, too, sometimes occur and bunkers must be entered to extinguish the fires or to remove the coal. Men entering bunkers should be compelled to use a life belt and line, the free end of which is securely anchored outside the bunker, and which is also in charge of a second worker. The second worker should always be on the alert to render assistance in an emergency. He should never leave his post while the man is in the bunker, and he should never enter the bunker without first securing additional help and himself donning a life belt and line.

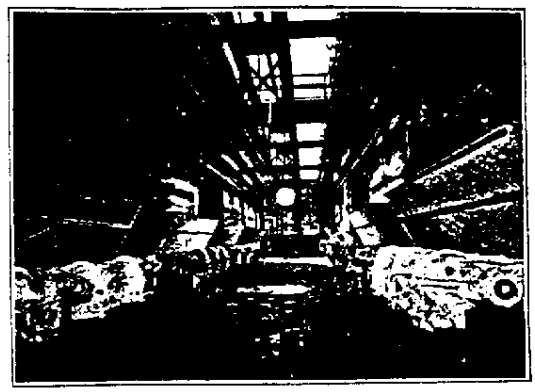
45. Since lighting facilities are usually poor in coal bunkers, battery-operated explosion-proof spotlights should always be available for emergency use.

46. If there is a fire in the bunker, precautions against asphyxiation should be taken as described in paragraph 29.

Coal firing

47. Coal in ordinary sizes may be fed into the boilers by hand firing or by automatic stokers. In either case, sufficient room and adequate lighting are two essentials for safety. Engineers and architects in designing power plants are usually very liberal in providing plenty of extra space in the engine room but some boiler rooms are too small for safe and efficient operation and for making repairs. The piping system should be well designed and so arranged that it will not be too close to the floor or other standing levels where operators may bump their heads or stumble over it. Suitable tools should be provided for the use of men in the boiler room and care should be taken to see that the tools are kept in good condition. (See paragraph 13 and Safe Practices Pamphlets No. 41 "Hand Tools" and No. 3 "Safe Operation of Steam Boilers.") Racks should be installed at convenient points where the tools may be placed when not in use. Many painful injuries have resulted when slice-bars and other heavy tools have been leaned against the wall or left lying about the boiler room floor. (See Figure 12.)

48. Automatic stokers present additional hazards of revolving and reciprocating machinery. All gears, chains, and sprockets should be completely enclosed with substantial metal guards regardless of their location or speed of operation. Flywheels, belts, pulleys, shafting (either smooth or containing keyways, etc.), clutches, etc., should also be guarded so danger of anyone coming into accidental contact with them will be eliminated. Particular care should be taken to lock the electric control switches, place tags on machinery, or in some other way give warning that the stokers should not be moved or operated when a man is adjusting or repairing them.



Courtesy E. I. du Pont de Nemours & Co.

Figure 12. A well designed boiler room. Note good housekeeping. (See paragraph 47.)

49. Sometimes flare-backs or explosions occur in boilers because of the generation of carbon monoxide or other flammable gases. They usually occur when the fireman breaks up a bed of coals or throws fresh fuel on the fire. Such hazards can be prevented, however, if the fireman makes sure that the damper to the stack is open before he opens the furnace door. When hand-firing a heavy charge of green coal, the fireman should leave a hot spot so that the volatile gases will be ignited and burn. This, too, will help to prevent flare-backs and furnace explosions. Boiler attendants should be instructed never to attempt to shovel floor sweepings, or other fine coal dust into the furnace since it will invariably flare-back as the dust cloud ignites. The sweepings should be wrapped in newspaper before being deposited in the fire-box, or if the boiler is stoker-fed they can be placed in the hopper.

50. Boilers should be equipped with safety latches on fire doors to protect the fireman from injury in case a boiler tube breaks and causes a flare-back or explosion. Screens of light weight steel chains are often suspended in front of the fire doors to shield the fireman from excessive heat when the fire doors are open.

51. The proper feeding of coal to a manually fired boiler requires skill and concentration. The fireman should have a clear, smooth area in front of the boiler on which to stand so he can give all his attention to properly placing the coal on the fire bed and not have to watch his footing. It is advisable, also, for the fireman to keep a broom handy to sweep up any loose coal after each firing.

52. In attending any boiler it is necessary for the fireman to observe the condition of the fire from time to time. A glance at the dazzling furnace light will frequently blind a man for several minutes thus materially increasing the danger of his being injured. Frequently peep holes are covered with colored glass to shield the fireman's eyes, or if he is firing by hand he may be provided with suitable goggles. Probably the best type of goggles for this purpose has the upper part of each lens colored and the lower half clear glass. The fireman can then look through the colored portion of the lens when observing the fire, and through the clear portion when picking up coal. On stoker or hand-fired boilers, where it is necessary to slice the fires for several minutes at a time, the protective glass is incorporated in a face mask which is worn to prevent the intense heat from burning the face. Hand shields, which are held in front of the face with one hand are also used where a prolonged inspection of the fire is made.

Ash handling

53. Ashes may be moved by hand-shoveling, wheelbarrows, carts, trucks, conveyors of different types, and by practically any of the means listed in paragraph 14. Precautions are then necessary as discussed in paragraphs 15 to 24. In some plants the ashes are conveyed through special pipe lines, propelled by steam jets, compressed air or water. Where steam is used in this way, it is advisable to locate the ash

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receiving bins outside the plant in a fairly remote place where an explosion would do the least damage. The action of the hot clinkers is apt to break up the steam into hydrogen and oxygen, and the former may explode if ignited from red hot ashes or from any other spark or flame.

54. Ashes are often dumped from the boiler grate while they are still red hot. Usually it is advisable to quench the ashes with water as soon as they are dumped. This should preferably be automatic for if water is applied after the hopper, car, or other ash container has been heated by the hot ashes, its sudden cooling will impose a severe strain upon the structure. When wetting down ashes with a hose, workmen should stand back so they will not be burned by a sudden rush of steam and so they will not be injured in case there is an explosion of the hydrogen as outlined in the preceding paragraph. Furthermore, under certain conditions carbon monoxide may be generated by the hot ashes; this may explode if ignited, or because of its poisonous character it may kill the workmen who breathe it. The dangers from carbon monoxide and hydrogen can be minimized by making sure that the ashes are thoroughly quenched with water and by providing plenty of fresh air and good ventilation in the places where the ashes are handled. If plenty of air can get to the ashes, carbon dioxide will be formed instead of the dangerous carbon monoxide. Good ventilation will carry off any hydrogen, carbon monoxide or carbon dioxide that may be generated. When using a hose about a power house for any purpose, workmen should carefully avoid wetting hot castings, or pipes or fittings that contain steam or hot water. Fracture or serious explosions may otherwise result. For similar reasons wet ashes should not be piled up against the boiler front or be allowed to accumulate near steam pipes.

55. Goggles should be worn by all men handling coal or ashes. Ashes particularly, when lodged in the eye, cause considerable pain and even serious injury. Good strong shoes are also necessary and safety shoes are recommended. Workmen should be particularly careful when walking on piles of ashes. Their feet may go through the cooled surface into a mass of hot ashes underneath. The danger of foot burns is particularly great if men enter the boiler combustion chamber before fine cinders and soot are removed. When entering the combustion chamber, men should wear heavy gloves, goggles, hoods are advisable, and coveralls tightly fastened at the neck, wrists, and ankles. The hooded boiler inspector's overall is an excellent type for this work. In some plants, it is now the practice to have men wear hard hats to prevent injuries from falling slag. The fine soot adhering to the walls and roof of the furnace retains heat for a long time and when disturbed it may fall and seriously burn the operators. Where ashes are removed by cars operating under the boilers, men are sometimes burned by hot ashes dropping through faulty hoppers or hopper doors. Hoppers and hopper doors should be kept in the best possible condition. In some plants, tell-tale chains are hung around the hoppers. Men will then walk around the hoppers rather than run the risk of striking their heads against the chains.

Pulverized coal

56. In many plants the boilers are designed to burn pulverized coal. The coal is generally received in run of mine size and pulverized at the plant either in unit pulverizers or central (bin system) pulverizers.

57. In the unit system, the coal is fed directly from the slack coal hopper through scales and feeder devices to the unit pulverizers. In most instances, two unit pulverizers are supplied for each burner. The coal is not dried before feeding it to the pulverizer, but air heated from 300° to 400° F. (plus or minus) is used to blow it into the pulverizer. The powdered coal, after passing through the pulverizer, is blown through the burner with air, from the air pre-heater, at about 400° or 500° F. (See Safe Practices Pamphlets No. 97, "Pulverized Coal Systems," and No. 3, "Steam Boilers—Operation.")

58. In the bin system, a central pulverizing plant is maintained and the coal thus powdered is delivered to individual storage bins from which it is blown by compressed air to the burners. In this system, flue gas, which is relatively inert due to its low oxygen content, is sometimes used as a drying and transporting medium. This procedure lessens the hazard of mill fire and explosion.

59. While a thorough comparison of these two systems is not within the scope of this pamphlet, a brief discussion is in order. The capital investment for the unit system is lower than that for the bin system. The steaming capacity of the boiler, however, is limited to the output of the unit pulverizer and, if the pulverizer is shut down, the boiler also must be shut down. In the bin system, on the other hand, storage facilities must be provided which introduce the hazard of spontaneous ignition and increase the hazard of dust explosion. If all points are considered, however, there is but little difference in either the efficiency or safety of the two systems.

60. Regardless of the system used for burning pulverized coal, there are certain fundamental hazards which must be taken into account if spontaneous ignition and coal dust explosions are to be prevented. Cleanliness about the premises is essential since a mixture of pulverized coal dust and air is explosive. As a matter of fact, a mixture of 30 per cent pulverized coal dust and 70 per cent finely powdered shale, mixed with the proper proportion of air, is known to be explosive. For this reason, coal dust which has settled on floors and girders of industrial plants, even though

Courtesy American Car & Foundry Co.
Figure 13. Lighting gas or oil burner. Man is standing well back and to the side. (See paragraph 73.)

it is mixed with inert dust, still may be productive of explosions and fires unless it is removed. Dust collected from the interior of buildings using pulverized coal has been found, in some instances, to contain as high as 23½ per cent volatile matter. Dust containing from 10 per cent to 15 per cent of volatile matter (coal dust) is said to be explosive. It is very desirable to reduce to a minimum the horizontal surfaces within the mill piping system where pulverized fuel can collect. Wherever the surfaces of pulverized fuel piping, equipment, or bins are exposed to cold air, they should be properly insulated to prevent condensation from forming within the equipment. Moist surfaces will cause the pulverized coal to "hang up," thereby promoting the spontaneous ignition and clogging.

61. Magnetic separators should be installed so that any tramp iron will be removed from the coal before it enters the primary crusher or the pulverizer. This is necessary since tramp iron or steel may damage the mill. Each separator should be guarded against the passage of coal when the separator is not magnetized. This can be done either with an electrical interlock that will shut down the coal supply when the magnetic circuit fails, or by means of a warning bell which will call the attention of the operator to the fact that the separator is not working.

62. It is a fundamental rule that coal dust explosions can be prevented, first, by preventing the ignition of mixtures of air and finely divided coal particles as may accidentally occur, and second, by preventing such mixtures from occurring.

63. Ignition may be caused by a flame, static electric spark, a spark resulting from striking together two pieces of metal, a live electric spark, excessive heat, lightning, fire, or spontaneous heating. To prevent ignition, open lights around pulverizing plants should be prohibited, and the men should not be permitted to smoke while in this building. The dryer and dryer furnace should be separated by a fireproof partition from the pulverizing mills, conveying machinery, and storage bins. A dryer should never be stopped while it contains coal.

64. Thermometers and pyrometers, preferably recording, should be used to check the temperatures of the pulverized coal in the bins and dryer so that overheating can be prevented. It should be the duty of one of the men on each shift to take one or more readings of these instruments. When bins are empty, they should be cleaned, preferably by washing down with a hose.

65. Pulverized coal bins should not be located near furnaces, boilers, steam pipes, or other sources of flame or heat. The coal should not be sent to the storage bin if its temperature is over 150° F., but it should first be cooled.

66. When a plant is shut down for a few days, all storage bins should be emptied of coal where this is possible. If this cannot be done, the bin should be carefully inspected for hot coals before the plant is again put into operation. Flashbacks which sometimes cause ignition of coal in storage bins can be prevented by opening the damper at the stack when lighting the burners, and by maintaining a higher air pressure in the coal line than in the line supplying air to the furnace. If the pipe carrying coal to the furnace clogs, the furnace should be shut down at once. Supply pipes should be blown clean of coal at the end of each day's work.

67. No coal line or bin should be opened near a flame or open light, and all electrical switches, wire and electrical accessories should be of the explosion-proof type (vapor-proof) so they will not offer sources of ignition.

68. All electrically driven equipment should be provided with remote control devices so the current for light and power can be shut off in an emergency without it being necessary for the worker to enter the pulverizer house. All belts, shafting, machines, and metal equipment should be electrically grounded.

69. The formation of explosive mixtures of dust and air can be prevented by proper building and equipment design; wetting down the dust before using a brush or a broom; installing adequate ventilating and vacuum cleaning equipment (not portable); making all conveyors, bins and pulverized coal equipment dust-tight; venting to the atmosphere all bins, pulverizers and other equipment where the operation does not depend on blown or compressed air; providing automatic devices to indicate the amount of pulverized coal in each bin; immediately plugging or otherwise repairing all leaks in lines, bins and fuel handling equipment; and making certain that the pulverizers are empty before they are stopped. Other factors of importance include proper design, construction, location and layout of buildings and equipment, the provision of suitable fire-fighting apparatus, and above all, the maintenance of good housekeeping at all times. (For additional information, see Safe Practices Pamphlets No. 34, "Industrial Explosion Hazards," No. 52, "Static Electricity," No. 53, "Checking Plans and Specifications for Safety," No. 97, "Safe Operation of Pulverized Coal Systems.")

Fuel Oil

70. Many different grades of oil are sold as fuel oil, but it is advisable to use in oil-burning equipment only those oils which have a flash point above 150 degrees F., closed-cup tester. (For information on the methods and apparatus for determining the flash points of oils, see Report of Test No. D 93-36 of the American Society for Testing Materials, 260 So. Broad St., Philadelphia, Pa.) The regulations of the Bureau of Explosives, 30 Vesey St., New York City, should be followed when fuel oil having a flash point below 80° F. is shipped in tank cars, barrels, cans, or other containers. After containers have been emptied, the covers, plugs, or bungs should be replaced at once; this will eliminate the possibility of a fire or explosion resulting from the ignition of the fumes and small quantity of oil that always remain after the container has been "emptied."

71. Storage tanks for fuel oil should preferably be underground either outside or under buildings. They should have at least a 2-foot earth cover or reinforced concrete protection. The tanks should be coated on the outside with a rust-resisting compound before burying. The distances the tanks are placed from buildings, if buried outside, should be those recommended by the National Fire Protection Association. These distances vary from 10 feet to more than 50 feet, depending upon the amount of fuel oil to be stored and the flash point of the fuel oil. Storage tanks placed above ground should be governed also by the National Fire Protection Association regulations as to the distances from buildings. Construction of tanks should also conform to those given in

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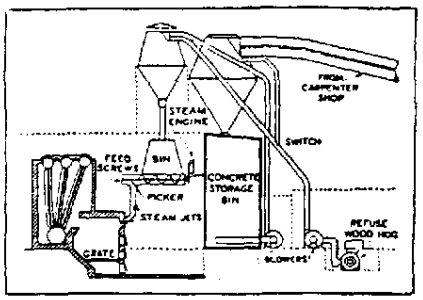

Courtesy "Factory Mutual Record" and General Electric Company

Figure 14. A good wood refuse burning system. Diagrammatic sketch showing the layout of a typical system for handling and burning wood refuse. (See paragraph 82.)

the aforementioned regulations. Where local ordinances govern the installation of such equipment, they should, of course, be followed unless those of the National Fire Protection Association are more stringent.

72. The National Fire Protection Association in its pamphlet on "Regulations for the Storage and Use of Fuel Oil" gives detailed information concerning the construction, setting, and venting of tanks, piping and pumping arrangements and other points of importance. The recommendations of this Association are subject to revision. The latest copy of this pamphlet can be secured by writing to the National Safety Council, or to the National Fire Protection Association, 60 Batterymarch Street, Boston, Mass. Underground storage tanks for hazardous liquids, constructed under established standards, are regularly inspected during the course of construction and labeled by Underwriters' Laboratories, Inc., 207 E. Ohio Street, Chicago, Illinois. A list of manufacturers of such tanks may be obtained upon request.

73. Some grades of fuel oil are so heavy that it is necessary to heat the oil to make it flow freely through the piping system. In no case, however, should heat be applied in any way other than by steam or hot water. If the oil is heated in a storage tank, it should be done by means of properly installed coils within the tank; the oil should not be heated to a temperature higher than 40 degrees F. below the flash point, closed cup. Thermostatic control and thermometer should be provided with all heating devices.

74. The use of naked flames such as lamps, torches, etc., should not be permitted around storage tanks or other fuel oil equipment except when needed to light the burner. Electric lights should be installed at all points where artificial illumination is needed; even then all electric equipment should be installed as specified in Safe Practices Pamphlet No. 34. Extension cords should be used only when made of theatre cable or of cord protected by armored cable. This should be fitted with keyless socket, vapor-proof globes, and heavy cage guards.

75. All fuel oil equipment should be carefully inspected at regular and frequent intervals and all leaks repaired immediately.

76. Before workmen are permitted to enter tanks that have held fuel oils, tests for the presence of toxic or explosive gases in the tanks should always be made. Some companies insist that men wear supplied air masks even where tests indicate the atmosphere in the tank is safe. Masks, of course, should always be worn in tanks where welding is done unless a continuous supply of pure air can be assured by forced ventilation. It is good practice where fuel oil tanks have not been thoroughly cleaned and tested to insist upon the men wearing supplied air masks. Where tanks have been thoroughly cleaned and tests indicate that the air is pure, and furthermore that a supply of pure air is afforded by forced ventilation, masks need not be worn.

77. Workmen who enter tanks should be provided with a life belt and a life line. The free end of the life line should be anchored outside the tank and it should be in charge of a second workman who can render assistance in case of emergency. The second worker should never leave his post while the man is in the tank, and he himself should not enter the tank without first summoning other assistance, donning a life belt and a life line and a supplied air mask.

78. Workmen should be particularly careful before lighting fuel oil burners to make sure that the furnace is well ventilated and that all dampers are open. The operator should stand back and to one side as far as possible so that he will not be burned or injured in case of a flare-back. When automatic igniters are not installed, it is best to use a metal torch not less than 4 feet long with a piece of oil-soaked waste tied to one end. This should be lighted, held in front of the burner tip, and the oil valve then opened. If two valves control the operation of the burner, both valves should be close together and so placed that the workman can stand back a little when starting the fire. It is advisable not to attempt to light a burner from the heat of the furnace or in any way other than by holding a flame in front of the burner. The installation of pilot lights has been suggested, but in case the pilot light goes out accidentally there is danger of gas or oil accumulation in the furnace which may flare up or explode when the burners are first lighted. (See Safe Practices Pamphlet No. 3, "Safe Operation of Steam Boilers," for additional operating data.) (See Figure 13.)

79. A newly lighted burner should be watched carefully; in case it goes out due to cold oil, furnace, or burner, the oil may drip out and accumulate under the burner. This may catch fire or cause an explosion when an attempt is made to relight the burner. It is advisable to have automatic devices which shut off the main oil feed in case the pressure drops too low to maintain a flame at any burner, or if the flame goes out for any other reason. The installation of such a device will greatly reduce the possibility of furnace explosions should one or more burners go out.

80. Included among the fuels used for heating boilers are natural gas, manufactured gas, and waste gases from blast furnaces and other special process furnaces. The principal hazards encountered in the use of gas include the danger of leaks in the piping system, ignition by flame or sparks, workmen entering tanks without life lines and suitable fresh air devices, and fire or injury resulting from improperly lighting the gas burners. These hazards are practically the same as the ones met with in plants that burn pulverized coal or fuel oil. They are discussed in considerable detail in preceding paragraphs, and the reader should refer to them for further information. American Gas Association standard methods for cleaning and testing should be followed when preparing tanks to be entered by workmen.

Wood Refuse

81. The use of wood refuse presents a fire hazard quite similar to that pre-

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sented by the use of pulverized coal. Wood dust in the air if ignited is capable of producing an explosion. Some of the same precautions, therefore, should be taken as outlined in paragraphs 56-65, such as removal of nails and scrap metal before the wood is fed into the wood hog, elimination of clogging in air ducts and chutes, installation of fire dampers in ducts and chutes to prevent flashbacks and spreading of flames, installation of open or automatic sprinklers in collectors and storage bins, elimination of open lights and smoking in rooms containing dust-laden atmosphere, location of collectors and storage bins away from boilers and other sources of excessive heat, etc.

82. A good wood refuse burning system as operated in a plant having a supply of scrap adequate for its fuel requirements is illustrated in Figure 14. Two ducts carry sawdust and shavings through a cyclone collector into the main concrete storage bin. From the bottom of this bin, a blower controlled from the boiler room, picks up the light refuse as needed and delivers it to a small collector on the roof of the boiler house. From there, it drops into two sheet metal bins under the boiler room ceiling. The sides of these bins taper outward at the bottom so the refuse cannot become jammed or clogged. At the bottom are three enclosed screw conveyors side by side, run slowly by a small steam engine mounted on a platform and controlled by an automatic governor which varies the speed inversely with fluctuations in the boiler pressure. As the wood waste is fed from the screw conveyor, a picker, driven by the same engine and having slowly moving dogs, breaks up any matted accumulation and thus prevents clogging. The material then drops down the feed pipe and steam jets blow it as a cloud into the firebox, where it burns in suspension, so that maximum combustion is obtained with little or no smoke. The steam jets tend to prevent flash-back in case of poor draft; but if a flash-back should occur, the fire could not reach the feed bins without first burning through the tightly packed refuse in the screw conveyors.

83. Old boxes, barrels, boards, and other refuse is run through a wood hog which chips it into small pieces. If clean, it is blown to the large collector and from there dropped to the storage bin. If the material might cause spontaneous ignition in storage, or if it contains nails it is blown to the smaller collector and used immediately.

84. The cyclone collectors and concrete storage bin have open sprinklers controlled by conveniently located quick-opening valves, so that water can be quickly applied to any fire which might reach the material in storage. In addition to safety, this arrangement gives the definite operating advantages of increased steam efficiency, smoke elimination, and small labor expense.

85. In some sections of the country, "hogged" wood is purchased from lumber mills by companies who do not have enough wood refuse to furnish fuel for their boilers. This hogged wood is loaded on barges at the mills by conveyors. The barges are then towed by river tugs to the customers' plants. Most plants use clam shell buckets for unloading the hogged fuel into conveyor hoppers. Conveyors then carry this fuel to outdoor storage piles or into the power plant fuel bin. Either chain or belt conveyors are used for handling the fuel. For storing and reclaiming hogged fuel, drag rakes operated by cables are used.

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