

ART. XXXIV.—*On the Explosion of the Flouring Mills at Minneapolis, Minnesota, May 2, 1878, and the Causes of the same; by S. F. PECKHAM.*

As I was sitting at the tea-table on the evening of May 2d, I was startled by a noise that sounded as if something as heavy as a barrel of flour had been tipped over on the floor above. A few seconds later the sound was repeated, and we all ran to the door which commanded a full view of the falls and manufacturing portion of the city. An immense volume of black smoke enveloped the spot where the Washburn A Mill had stood, and a perpendicular column of smoke was projected into the air above the elevator at least four hundred feet. The Humboldt and Diamond Mills were directly behind the elevator from the place where I stood. A heavy wind was blowing from a point a little to the east of north, a direction from the Washburn A Mill toward the elevator and the other two mills. In less than two minutes from the time of the first explosion, the elevator, which was 108 feet high, was wrapped in flames from top to bottom. If the structure had been saturated in oil the flames could not have spread much more rapidly. In five minutes flame and smoke were pouring from every window in the Day & Rollins, Zenith and Galaxy Mills, which were between the Washburn A Mill and the river, producing a conflagration which from ordinary causes would not have gained such headway in two hours. Six flouring mills, the elevator, a machine shop, blacksmith's shop and planing mill, with a number of empty and loaded cars, were in flames in five minutes from the time fire was first observed by any one who survived the disaster.

From my own point of observation, which was about a mile distant, but two distinct explosions were heard; others nearer heard three, the first not as violent as the other two; while those nearer still heard in addition a sound which they described as a succession of sharp hisses, resembling the sound of burning gun-powder. Those observers to the windward, whose attention was arrested by the light produced, beyond the distance of half a mile, heard only one or two reports or failed to hear any report at all. From all the testimony in reference to sound it appears that the blow upon the air was not sufficiently sudden to produce a penetrating sound, but rather a dull, heavy blow, which was not communicated laterally to any great distance.

Burning wheat or flour was smelled for several minutes before the explosion by persons in such a position that the wind would carry the odor to them. Smoke was also seen issuing from what was known as the exhaust flour-dust spout

of the Washburn A Mill for several minutes preceding the explosion.

At the instant the explosion occurred all observers agreed that the Washburn A Mill was brilliantly illuminated from basement to attic. The illumination was reflected from the water at and around the falls in such a manner as to remind one observer of the effect of a brilliant sunset. Another compared it to the reflection of sunlight from windows when the sun is near the horizon. Still another, who was crossing the lower bridge, had his attention called to what appeared to be a stream of fire, which as he described it, issued from a basement window and went back again. Immediately thereafter each floor above the basement became brilliantly illuminated, the light appearing simultaneously at all the windows, only an appreciable interval of time intervening as the stories ignited one after the other. Then the windows burst out, the walls cracked between the windows and fell, and the roof was projected into the air, followed by an immense volume of smoke and flame which ascended to an estimated height of from six to eight hundred feet. As the column of smoke was expanded and borne off upon the wind, brilliant flashes resembling lightning passed to and fro.

Two men, so near the Humboldt Mill that they were nearly buried by the falling rubbish, and on the opposite side from the Washburn A Mill, heard a loud report distinctly while the walls of the Humboldt Mill were still standing and at the same time were knocked down. Immediately after they saw flames issuing from the basement windows of the Humboldt Mill and at the same instant, before they could regain their feet, they experienced a second shock and miraculously escaped being buried beneath the falling walls.

The enormous and sudden displacement of air which followed the explosion, and the tremendous force which was consequently exerted laterally, was shown in the condition of the round-house of the Chicago, Milwaukee, and St. Paul railroad, and the broken windows in all directions. The round-house was a wooden structure about forty or fifty feet from the Diamond Mill. The sills were drawn out toward that mill until the building burst, letting a part of the roof fall in and leaving the sides standing at a sharp angle. Ordinary windows, and those of strong plate-glass on Washington avenue one-fourth of a mile distant, were projected into the street. Not only the glass but the sash went out bodily, particularly in the lower stories of the buildings. Persons on the river at the water's edge noticed a displacement of the water producing a wave estimated to be eighteen inches high, before they heard the report of the explosion.

Whole sheets of the corrugated iron with which the elevator was covered, measuring eight by two feet but quite thin, were picked up on the east side of the river more than two miles distant, and pieces of six-inch flooring from two to ten feet long were carried to intermediate points.

An examination of the ruins of the several buildings showed that the walls of the Humboldt Mill lay upon those of the Diamond Mill, and those of the Diamond Mill upon those of the west end of the Washburn A Mill, showing that the buildings did not explode simultaneously but successively. The Washburn A Mill evidently exploded first from fire originating within it, and the high wind prevailing at the time carried the *flame* into the adjoining mills to the south and away from the mills next the river. There was enough burning middlings and flour thrown through the broken windows of the latter mills to set them on fire, but they did not explode. Some significance may attach to the fact that the three mills that exploded were all running with more or less open French middlings purifiers, while the three that did not explode had been shut down for several days. There is no question but that the French purifiers project a great deal more dust into the atmosphere of the mills than those that are enclosed, but I have no doubt that in *any* flouring mill sufficient dust accumulates upon beams and machinery to produce an explosive atmosphere if from any cause this dust is scattered into the air and flame is communicated to the mixture while the dust is suspended.

There was less than a barrel each of lard oil, lubricating oil and high-test kerosene in the Washburn A Mill at the time of the explosion.

There is absolutely no proof that any explosive material other than is produced in the manufacture of flour from wheat was in any one of the buildings destroyed, in the cars around them or in the neighborhood. The testimony of mill-wrights conclusively showed that fire produced by heated bearings is of such extremely rare occurrence in flouring mills as to practically exclude such a cause.\* No suspicion of incendiarism has ever been expressed.

A slight fire, the effects of which were in no wise serious, occurred in the Washburn A Mill about three months before the explosion. It was discovered from the outside of the mill that smoke was issuing from a spout or conductor that discharged the air that was drawn through between the stones.

\* These gentlemen concurred in the statement that the spindle which carries the stone had been known to become *welded* into the socket in which it revolved, stopping the stone. When asked if the friction produced a welding heat, one replied, "no, no where near it." It must be an example of perfect metallic contact, producing cohesion.

The object for which the air is drawn through is to cool the stones and to carry off the vapor produced from the wheat by the rise of temperature due to friction. In this case the effects of *fire* were traced back from the outside of the building to one of the sets of stones on the north side of the mill used for grinding middlings. The effects of *flame* however did not extend beyond the blower which produced the exhaust. This led to the conclusion that the fire did not enter the dust-house, although the smoke must have passed through it. It is supposed that the fire was caused by friction between the stones, they having run dry from one of the causes that may produce dry stones.

In answer to enquiries made of several millers in the Minneapolis mills, I found them uniformly of the opinion that the meal or flour as it left the stones had a temperature of about 100° F. or less. A number of careful experiments, made with an ordinary chemical thermometer, showed that the wheat enters the stones from the dryers at a temperature of fully 100° F. and that it leaves the stones at 120°–130° F. The temperature of the ground middlings as it left the stones averaged about ten degrees higher.

It was also the concurrent testimony of millers and mill owners that dry stones are of comparatively frequent occurrence, and that they are practically unavoidable. I am convinced that in the Washburn A Mill the frequency of danger from dry stones was considerably increased in consequence of the large number of stones in the mill, and especially from the fact that so few men were employed having the immediate oversight of the stones. Only two men were employed at the same time for the forty-two run of stone, a number inadequate for that supervision which so important a matter demands, as it is impossible from the large space occupied by so many stones and the noise incident to their action, that even with the usual signals employed dry stones should be detected as soon as they become a source of danger.

Obstruction of the feed from any one of a number of accidental causes will produce dry stones. The danger arises from the friction of the stones heating the last portion of the grist that remains between the stones to a temperature sufficient to char it, or convert it into a substance resembling tinder, which would readily ignite from a spark produced by the stones striking together. Another source of danger arises from nails or gravel passing between the stones with the grist and increasing the friction, producing either a rise of temperature or a train of sparks; perhaps both.

I am aware that numerous instances of dry stones can be cited that have proved perfectly harmless. An instance is on

record in which a run of stone ground each other all night with no other result than the complete removal of the grooves which gave the stones a cutting face. On the other hand, cases have occurred in which the grooves became filled with charred wheat of a dark-brown color, packed into them so solidly as to require a mill-pick for its removal. It requires no argument to show that this tinder thus formed, would become ignited from a train of sparks that would inevitably follow contact of the stones as the grist became compacted or completely removed from between them. It was found by experiment\* that masses of flour that had become heated and charred, ignited readily and smouldered, but were inflamed with considerable difficulty; but it should be borne in mind that a number of sets of these stones are connected with a common spout or conductor, through which a strong current of air is being continually drawn and which is filled with a dense cloud of very fine particles of starch (chiefly) heated to a maximum temperature of 140° F. Experiment also proved that the proper mixture of flour-dust and air would not burn explosively except when brought in contact with *flame*. White-hot wires and glowing charcoal only burned the particles in contact with them. But it was found that burning pellets of charred wheat and flour would ignite wood which a strong draft of air readily fanned into a blaze. Under the conditions previously stated with a draft of air passing through the dry stones strong enough to convey the pellets of smouldering tinder into the common wooden conductor an explosion becomes possible.

It is urged that these conductors are damp from condensed moisture, and also that a large amount of moisture escapes from the wheat and is conveyed away by the current of air. This loss is no doubt correctly estimated at from five to six per cent. It is, however, chiefly during the first grinding of the raw wheat that this loss is experienced. The middlings is dryer, is ground at a higher temperature and is ground finer, producing more dust. The higher temperature renders the material more inflammable and at the same time ensures a more complete solution of the vapor in the current of air. Moreover, the first fire in the Washburn A Mill was traced directly to a set of stones which ground nothing but middlings, and all that is known concerning the origin of the fire that produced the explosion confirms the supposition that that fire originated in a set of stones on the opposite side of the mill, which was one of six sets, all of which were used exclusively for grinding middlings, discharging into a common spout or conductor which communicated directly with a dust-house in which the

\* Experiments made by Professor L. W. Peck before the coroner's jury.

dust settled to the amount of several hundred pounds a day. An explosion in this conductor, communicating *flame* to the dust-house, would scarcely fail to cause the successive explosions of the dust-house and the different stories of the mill, the shock of the first explosion being sufficient to throw the dust of the mill into the air.

The opinion expressed by one of the witnesses at the inquest, "that stones are liable to run dry at any time by accident," and that "dry stones can hardly be avoided by any amount of foresight," appears to be generally entertained by millwrights, millers and mill owners. Let it be granted that all experience shows that ninety-nine per cent of dry stones injures nothing but the stones themselves, the one per cent of residue is burthened with fearful possibilities. If dry stones cannot be prevented in small mills where one miller has charge of perhaps six run of stone, the danger is more than proportionally increased in a mill where one man has charge of twenty run, both with reference to prevention and detection. The problem therefore for the consideration of parties immediately interested is, how to prevent or detect dry stones, particularly those used for grinding middlings. This practical problem appears to be fundamental and one compared with which all others are without much importance. It is true that but few millers are without their experience of minor explosions or flashes resulting from careless use of lanterns or open lights. Indeed, I have been profoundly impressed with the generally innocent reputation of flouring mills when considered in the light of the immense number of accidents well-known to millers and insurance companies; a number surprisingly large if confined to those occurring in the States of Minnesota and Wisconsin within a few years past. The remedy in such cases is so obvious that the most ordinary care and intelligence is sufficient.

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