EXPLOSION OF A FLUE BOILER.

The following criticism and analysis of the destructive explosion of a rolling-mill boiler, by the collapse of a large flue, which occured some months ago, will be found interesting and instructive. The case is presented in the monthly bulletin of the Hartford Steam Boiler Inspection and Insurance Company.

The boiler that exploded was a cylindrical, horizontal, single-flue, built about 1870, and was 20 feet long, 4 feet diameter, made throughout of iron not less ⅜ of an inch thick. The flue was 22 inches diameter, and extended from end to end. The boiler was placed over a re-heating furnace, and heated by the waste gases, which entered the chamber below the boiler at the rear end, as indicated by the arrows in Fig. 2, passed the whole length of the boiler in contact with its lower half, and returned by way of the flue to the chimney. The boiler was supported at a height of 10 or 12 feet above the ground by three pairs of cast-iron brackets, which were riveted to the shell and rested upon the side walls. The boiler had flat wrought-iron heads flanged to the shell and flue, and stayed by 12 braces about 4 feet long, part of which were fastened to T-iron placed horizontally above the flue, one on each head, and the inner ends of the braces were attached to the ring of shell plates that joined each head, as shown by the dotted lines S, S, etc., Fig. 2. This boiler was one of a system of ten which were similarly set and heated, all connected to two or more main steam pipes, and each provided with a steam stop-valve, a safety valve, and three gauge cocks, but each did not have a steam gauge. This particular boiler being without a steam gauge, there was no means of ascertaining the pressure when the stop-valve D was closed, except by such indications as the 2-inch patent lock-up safety valve afforded. This boiler was supplied with water (the temperature of which is not known, but probably variable) at intervals through the pipe A, Fig. 2, as often as it got low, and no doubt as rapidly as could be done with the pump or large injector. The blow-off pipe B was located at the bottom, and afforded means of completely emptying the boiler.

About 5 o'clock in the morning, the steam stop-valve D had been closed for an hour or so to repair a steam pipe, and the 2-inch lock-up safety valve C (which had neither cover nor lock), had been blocked open by means of a bit of wood placed inside the case, to relieve the boiler while the repairs were going on. The repairs done, the attendant let down the safety valve, and was about to open, or had partly opened, the steam stop-valve, when the explosion occured. The engravings have been prepared from photographs and sketches, and the case has been made up as well as could be from them and the published evidence given to the coroner's jury The boiler shell, Fig. 1, containing 3½ lengths of the flue, flew through the roof of the mill, taking a direction so that it landed nearly in a line with its projected axis, at a distance of 130 yards from its working site, striking and demolishing a large area of the mill roof and a brick chimney in its flight. It struck the ground several yards short of where it stopped, and plowed a deep furrow in the ground, in which it lay partly embedded, the same end foremost that it had in the mill, by which operation the foremost head K was partly broken from the shell and the shell distorted something as shown in Fig. 1, in which the dotted lines represented the unbroken part of the shell; the shaded portion at the left shows the foremost parts of the shell broken by the fall; the shaded portion of the flue remained in the shell, and that portion in flue outlined was blown out with the missing portion of the head at the right. Of the parts of the flue that went with the boiler shell, that shown in Fig. 3 was dropped out in its flight at about one-third the distance made by the shell, while the other two, Figs. 4 and 5, remained in the shell, but entirely broken apart and from the head. The sides of the piece, Fig. 3, of the flue were shut together with such force as to emboss the forms of the heads inside upon the exterior surface opposite W, Fig. 3, and the two inner surfaces were in perfect contact, as though the iron had been soft as wax when the parts came together; but there was also visible at S, the very summit of the flue when in its place, a dark shiny, thin scale, which is often seen inside of boilers using a particular kind of water, which had not lost its glossy appearance or changed in color, indicating that it had not been hotter than usual since the scale was deposited there. Samples of iron having on them this kind of deposit have since been exposed to heat, and it is found that a heat sufficient to change a brightened spot on the iron to a blue color—say about 550° or 600° Fah.—is sufficient to blister a deposit and destroy its lustre.

The experts who testified before the coroner differ as to the cause of the collapse, and it is probable from the nature of the subject that they will always differ in such cases. Experts from the scientific schools and from the learned professions are seldom in perfect accord when giving testimony, and often their opinions differ so widely that it is necessary to appeal to common sense.

It is the object of the present writing to offer an unbiased technical discussion of this case in the light of this company's experience, and for the good of all whom it may concern.

This boiler was a fair sample of a one-flue boiler, both as to material and workmanship, capable of bearing safely, when sound, a working pressure of 70 pounds, which was about one-third of the collapsing pressure of the flue if it was round and sound. It was run as boilers usually are in works of this kind. A man of good habits was in attendance, who believed in plenty of water as a sure preventive of boiler explosions, and his practice was in perfect accord with his faith. He was on hand and attending to his duty, which was first, last and exclusively to see that ten boilers were fully supplied with water. He did not help repair the broken pipe; his attention was therefore not distracted by that event. The feed valve was open, the steam pump was in motion while the men were at work on the pipe. So swears the engineer who repaired the broken pipe. Other witnesses swear that the boiler attendant was about there trying the gauge cocks; that he was seen trying gauges a few minutes before the explosion. The master mechanic swears that he, the boiler attendant, was directed to fill up as soon as the water fell below the upper cock; that he saw no indications of low water in the exploded boiler. Thus much, and no doubt more, evidence might be quoted relating to the probability that water was or was not low in the exploded boiler; all of which would be of no account if the theory of low water was confirmed by the testimony of the flue itself and by the general character of the explosion. Is it so confirmed? The records shows that boilers which explode with no water in them, are not shot through the air like a rocket, and those containing small quantities go short distances. The records also show that large horizontal flues that collapse on account of being softened by heat, invariably cave in from the top only, and that lateral collapse is due to distortion of form or weakness at the side longitudinal seams from grooving or from thinning of the plate by corrosion. Two witnesses swear that grooving was observed, but as its location was not indicated little can be said about it. The parts not shown in the illustrations were cut to pieces and worked up, and no sketches or description of them were obtained. It must have been on those parts, if there was grooving, as none was found on the parts sketched.

Finally, to satisfactorily account for all the phenomena that attended this explosion, we have only to show that the safety valve was jammed so that it did not prevent the rise of the pressure, and that the stop-valve was closed, or just being rapidly opened, at the instant when the limit of endurance had been reached by the boiler; and as every circumstance and all the testimony confirm the latter requisite, we have only to imagine that this small valve, with its compound levers and disk weights huddled into a case of 8 or 10 inches diameter, and of less depth, which had been blocked open by means of a bit of wood placed against one of the levers when full relief to the boiler by its means was desired, was accidentally jammed when it was let down. The propositions below will not appear absurd to those who realize that over 3,000 cases of defective condition of safety valves, most of them originally correct and proper, had been detected by this company's inspectors during the first twelve years of its experience, out of which number 1,400 were reported as dangerous, and that thousands of defects have been reported that were dangerous only in the event of an accidental over-pressure.

The following proposition seems to account for all the phenomena of this explosion while the theory of low water does not: The hypothesis is, an accidental sealing of the boiler after the broken steam pipe was repaired, the stop-valve D being still closed (or in the process of being rapidly opened), and the safety valve jammed, the generating surfaces of the boiler in full action, the pressure rapidly rising, the flue—at the best only about half as strong as the shell—had acquired (from the sudden thermal changes, due perhaps to the influence of the cold feed-water among other abuses of its ten years' night and day work) an obscure weakness, flattening, thinning or grooving at a longitudinal seam, and the limit of its resisting power was soon reached at no *very* high pressure, and it collapsed near the middle of its length. The head L, being the weaker, for obvious reasons, of the two, gave way instantly when the shock of the collapse was added to its now extraordinary steam load, and it, with nearly half of the flue, fell inside the mill, and the expanding water began to issue from the open end of the boiler (the