from the enormous and instantaneous generation of steam which the safety valve was incapable of handling, and the boiler unable to stand, is about played out. This old standby has certainly done duty, in being given as a cause for explosions more, probably, than all others combined, and even no later than a few weeks ago, when a steam boiler in a hotel in Denver exploded with terrific force, entirely demolishing the building and causing the death of twenty or more persons, the daily press came out with the startling announcement that the fireman had allowed the boiler to run short of water and become red hot, and as the papers said, that when he turned the cold water on the "red hot tubular machinery, the boiler instantly exploded, demolishing the entire building," and that a crowd were out hunting the fireman, with the avowed intention of lynching him They omitted to state, however, how the fireman got out of the basement after turning the cold water on the red hot boiler, which caused the instantaneous destruction of boiler and building. The result in this case, as in many others, proved conclusively that there was plenty of water in the boiler, or if not, what was the source of the explosive energy which wrecked the entire building and caused the death of over twenty people.

I expect that some of the gentlemen present, who may still cling to the red-hot sheets and cold water theory as a cause for explosions, will not agree with me, but for their benefit I wish to make mention of some very practical tests which have been conducted by Mr. L. Fletcher, chief engineer of the Manchester Steam Users' Association in England, as early as 1867, when under his supervision, several steam-heating boilers were subjected to the test of being allowed to become red hot, when cold water was fed into them, with no more serious result than the springing of the joints and cracking of seams at the rivets from severe contraction.

A further test was conducted by the same gentleman, assisted by several engineers, in 1889 or 1890, during which test several large boilers (such as are used in mills and factories in England) under steam pressure were allowed to run short of water until the furnace crowns were red hot, when cold water was injected on the red-hot plates, without producing any explosion, or but even a very slight increase in pressure. As a matter of fact, however, the pressure in some cases decreased when the cold water was allowed to flow in on the red hot sheets. As these tests are of especial interest to us, and tend to dispel the generally accepted theory as to the cause of boiler explosions, I have embodied a summary of them in this paper.

Mr. Fletcher, in his report, says:—"Regarding the view to be erroneous, that an instantaneous and ungovernable amount of steam is generated by throwing cold water on the red-hot furnace crowns of a boiler, it was thought that it might be well, in the event of low water in a boiler, to turn on the feed, and thus reduce the pressure of steam, cool down the furnaces and arrest collapse."

While past experiments had proved that no injury would occur to the shell from the adoption of this course, the question was raised· What would be the effect on the furnace crowns?

This question was submitted to several engineers of experience, but though they were all fully aware that the specific heat of iron, compared with water, was so low that no large volume of steam would be generated, they all hesitated to give an opinion as to what might be the behavior of the furnace crown sheets under such treatment, and could suggest no other method of solving the problem than that of instituting a practical test. It was not an easy matter to make all the arrangements necessary for such a test, in the face of the predictions of the dire calamity which it was said by many would surely follow such an experiment, and, as might be expected, it was some time before a suitable site could be secured where the test could be carried out. At last a piece of open ground on the premises of the late Joseph Clayton, of Preston, and adjoining his boiler shop, appeared the most suitable, and that gentleman was good enough to consent to the tests being made there.

A boiler of the Lancashire type (internally fired), with plain furnace tubes, lap jointed and single riveted, was selected, and the furnace flues were not strengthened by either flanged seams or rings of any kind, as it was thought that furnace flues of this description would give a fuller test than a boiler of the more modern type of construction, in which the furnace tubes would be welded at longitudinal points and strengthened circumferentially with flanged seams or other similar means. The dimensions of boiler provided for this test were as follows, viz.. Length, 27 feet 9 inches; diameter, 7 feet, diameter of furnace tubes, 3 feet. The thickness of shell plates was $\frac{7}{16}$ inches, the heads were $\frac{9}{16}$ inches, and the furnace tubes $\frac{7}{16}$ inches. The material was of iron throughout. The heads were both stayed and strengthened by four gusset stays above the furnace tubes, while there were two of same stays at front end and one at back end below the furnace tubes. The fire grate was 6 feet by 3 feet, thus giving 18 square feet of grate surface in each furnace.

The boiler was set in the usual way and connected to a chimney and fitted with all the usual appliances, as if it were being laid down to run a mill, with the single exception that the feed-water pipe, instead of discharging the feed water between the furnace tube and the shell, as is usual, was carried immediately over the furnace crowns in order that there might be no doubt as to the cold water striking the furnace crowns when red hot. Everything was done to make a severe test, and, if possible, produce an explosion. All possible precaution was taken to prevent injury to those conducting the test, and a very strong barricade of heavy timber was built, into which were placed all the steam gauges, water gauges, feed-pumps, blow off cock, etc., and all other appliances necessary for the test. The steam gauges were fitted with a tell-tale finger which would leave no room for doubt as to the highest point reached by the pressure of steam in the boiler. From this barricade, the test could be carried on in safety, as I have no doubt but that it was placed well out of the line of danger in the event of the collapsing of the furnace tube.

Provision was also made for measuring the quantity of water pumped on the furnace crowns when hot. The manner of making the tests was as follows: At 5.42 p.m. both safety valves being open, and the water on a level with the furnace crowns, and the steam pressure at three pounds, the blow-off was opened full bore. At 5.54 p.m. the blow-off cock was shut, the water having been brought down sixteen inches below the top of furnace crowns, and only about two inches above the level of fire grates.

At 5.56 p.m., or 14 minutes after the water had commenced to leave the furnace crowns, both safety valves were closed, and the cold water feed turned on