

A section, equal to six horse-power, was "placed in an extemporary furnace, built in a clay bank, and set in the usual manner for a boiler of this kind."

"The boiler was filled with water to the regular height, say about two-thirds full, with no outlet or safety-valve of any kind, and sealed up tight, a small tube leading from the upper ball to a high-pressure gauge, placed at a safe distance, say about two hundred feet from the boiler. A fire was made under and around the boiler, with the fuel of dry pine wood. The wind was very high at the time of the experiment, blowing from the west directly into the furnace, thus fanning the flames to an intense heat.

"The gauge soon gave indication of the formation of steam, the pressure steadily increasing up to four hundred and fifty pounds to the square inch.

"At this pressure there seemed to be a sudden discharge of steam, as from a small opening. The discharge did not continue for many seconds, and the committee are not certain that it proceeded from the boiler; there may have been some water discharged from the bank of wet earth into the fire. The pressure then increased at a uniform rate until it had reached the enormous strain of eight hundred and seventy-five pounds per square inch, when a sudden discharge of steam took place, seemingly no greater in volume than might issue from a safety-valve of two and a half inches diameter, or even less; after which the pressure fell to four hundred and fifty pounds, at which it stood when the fire was drawn for examination.

"While the boiler was being uncovered for examination, a boiler of about twelve-horse power, consisting of two sections, similar to the ones previously experimented upon, was fired and steam raised to one hundred and twenty-five pounds pressure. This boiler had no safety-valve, but was provided with a globe valve of one inch capacity or area, as an escape valve to regulate the pressure in the boiler. When the committee examined this boiler at time of firing, it had two full gauges of water, the escape-valve was opened so as to reduce the pressure to one hundred pounds per square inch, and regulated from time to time to keep the pressure uniform at this point. The fire was pushed, and no more water was injected into the boiler. In due time the lowest gauge-cock gave no indication of water. Soon afterward a slight leak was observed in one joint of the left-hand section. This closed in a few minutes and one opened in a similar manner in the right-hand section; this also closed in a short time. No other leaks showed themselves during the experiment. As the water boiled away, the soot began to burn off the upper balls of the sections, that is, off those of the upper balls of the lowest row, visible through a peep-door above the fire-door provided for inspection. The boiler then became gradually red hot, and even when all the water seemed to be exhausted, and the pressure slowly fell, the gauge stood for some minutes at thirty pounds, as if from the vaporization of some water in the lower courses of the sections, showing that in this red-hot condition, the boiler was tight enough to hold pressure. After the fire had been drawn, and the boiler cooled, the bolts holding the units together were found to be

loose, as if stretched by the unusual heating of the cast iron surrounding them. During the time of the experiment with low water, the escape-cock was many times closed to increase the pressure, then opened quickly to reduce it to the one hundred pound standard, but with no deleterious result. When the gauge stood at thirty pounds, all of the boiler visible from the peep-door and fire doors, down to the bridge-wall of the furnace, was at a bright red heat. This was unmistakable, as when the fire was drawn, the boiler was hot enough to ignite a piece of wood held against it."

On the day following the trials, these boilers were carefully examined, and found to have sustained no material injury. The committee were of opinion, that the extreme pressure of eight hundred and seventy-five pounds had stretched some of the bolts, thus opening some of the joints, so as to act as safety-valves and relieving the strain on the boiler.

A third boiler, of twelve-horse power was tested by filling with water to the upper water-line; it was thus "fired until pressure was raised to ninety pounds, at which it was blowing off freely. The water was then all blown out by the blow-off cock, the pressure falling to sixty pounds while blowing off, at which it stood until steam reached the blow-off pipe, when the pressure fell to zero. It was kept empty for three minutes, with the fire still burning, and was then rapidly filled with cold water, and steam raised to one hundred pounds pressure in thirty minutes, blowing off at one hundred pounds, and was quite sound and tight."

A number of other experiments, of a character even more severe than the above were conducted, and with similar satisfactory results. The committee state that, "during the experiments, the employes of Mr. Harrison seemed quite fearless in their manipulations of the boilers, showing a confidence in their safety truly remarkable.

Mr. Zerah Colburn, as to the strength of these cast-iron spheres, compared with wrought-iron cylinder boilers, says,—

"The strength of a hollow sphere to resist internal pressure is exactly twice that of a hollow cylinder of the same diameter, material and thickness, and it can be shown that even a cast-iron sphere, seven feet in diameter and seven sixteenths of an inch thick, is as strong as the shell of a Cornish boiler of the same dimensions." "The plane in which rupture, if it happens at all, will take place in a hollow sphere, is the largest plane that can be drawn through it, and the metal resisting the strain tending to cause rupture is the whole section of metal bounding the plane." "In a hollow cylinder the area upon which the greatest pressure tending to cause rupture will be exerted is that represented by the product of the length into the 'diameter of the cylinder.'"

In closing their report to the Institute, the committee state that they "are impressed with the great utility of the boiler, as one perfectly safe and