MR. PRESIDENT AND GENTLEMEN,

My object in bringing the subject of boiler explosions before this Association is to call the attention of its members, who are mostly steam users, to the extraordinary number of these disastrous calamities which have occurred during the last twelve months in this colony.

It is very much to be regretted that no official record is kept of boiler explosions here, as there is in England; consequently many cases are lost sight of which would be useful in pointing to the rocks ahead which the steam user has to avoid.

A good many cases have come under my own personal observation, but I am greatly indebted to the Press for much of my information, and I know there are many members of this Association who can supply very valuable and useful information; and I hope they will do so, as the subject is of vital importance, not only to steam users, but every member of the community.

It is not my intention to enter into minute particulars of the different boiler explosions, but to give as brief an account as possible, and from these to draw conclusions as to the best methods of preventing such serious calamities in future.

On the 3rd of April, 1884, a locomotive engine, whilst drawing a heavy goods train up a steep incline at Rupertswood, near Sunbury, suddenly exploded, killing the engine-driver and seriously injuring the fireman. The force of the explosion was so great that a portion of the boiler, weighing over half a ton, was thrown to a distance of over 300 yards. A board of experts was appointed to inquire into the cause of the explosion, and
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reported that the cause of the explosion was due to certain repairs having been effected with defective boiler plates.

I think it very possible that the pressure of steam was raised very high with the view of enabling the engine to haul the heavy train up so steep an incline, and this extra pressure was too much for so old an engine.

This explosion proves that, though apparently a great amount of care may be exercised, boiler explosions will occur.

The next on my list is an explosion of a boiler at Footscray. This boiler was used as a vat, and carried about 40lb. pressure of steam for boiling purposes. It consisted of a shell and two flat ends, with only only one long 1\(\frac{1}{4}\)in. stay rod from end to end, and as the barrel of the boiler was 5ft. in diameter, it will readily be seen that such a stay would not prevent the ends of the boiler from bulging and flattening, until they weakened the angle-iron so much that it gave way round the root, blowing the end out of the boiler, and the boiler itself was shot through the roof of the building, doing about £300 worth of damage, but happily no lives were lost.

The cause of this boiler explosion was malconstruction—the ends not being sufficiently stayed, it was only a matter of time, not fair wear and tear, when this boiler was sure to explode.

I may here mention that this boiler was tested two or three months before by hydraulic pressure to twice its working pressure, and I cannot help saying here that this pernicious practice hastened the end of this boiler, as it has done hundreds of others.

No. 3 explosion occurred at a chaffcutting works in Ballarat East, in May, 1884. It arose from a steam boiler of the Cornish type. The whole of the boiler house was blown to shreds, and the boiler itself fared no better. One person (Mrs. Allen) was killed, and five others injured, besides which, property to the extent of over £600 was destroyed.

It is stated that the owner of the boiler and premises was repeatedly warned of the condition of the boiler, as some three months before the sad occurrence took place, a gentleman was in treaty for the purchase of the plant of which the exploded boiler formed a part. He found, hanging to the safety valve of the boiler, two halves of broken fire bars, each about six inches in length. He told the owner that if care was not taken the whole thing would blow up. He did not purchase the plant, as it seemed rusty.

From the appearance of the boiler after the explosion, it must have been in a "worn-out" condition for some time previous. Many of the pieces were seriously oxidised, and the plates in places reduced to 3-16th inch in thickness.
The boiler had been in use at the Band and Albion mine 25 years ago.

At the inquest an engineer deposed that about the middle of April he went to execute some repairs. In starting the engine he noticed the steam gauge registered 65 lb. per square inch. He told the owner that if that was the ordinary pressure it was not safe.

The cause of this explosion was the carrying too much pressure on an old boiler.

The eighth explosion was another painful reminder of the necessity of competent and periodical boiler inspection, and also boiler insurance.

On the 8th of November last a steam boiler at a tannery in Richmond exploded, by which one man lost his life, and six others were injured, three of them seriously. As there were some 40 persons working in the vicinity of the boiler, it is marvellous the loss of life was not much greater.

The manager for the firm, one of the former proprietors, states that the boiler had only been in use about three years, and that it was tested in July last to a cold-water pressure of 100 lb. per square inch, or twice the working pressure by steam gauge. I took the steam gauge, after the explosion, to the School of Arts, Ballarat, and had it tested by the mercury column, and it showed as much as 15 lb. wrong in some pressures, and when it showed 100 lb. the boiler was really pressed to 120 lb.

At the request of the owners, I inspected the boiler after the explosion. In my report I stated that the boiler was of the Cornish type, 14 ft. 3 in. long by 4 ft. 10 in. diameter. The plates of the barrel and flue were constructed of 5/16 in. iron, the end plates being 3/4 in., while the angle iron rings were only 2 1/16 in. by 3/16 in. There were no stays of any kind whatever.

To the lightness and poor quality of the angle iron, together with the entire absence of stays, must be attributed the bursting and consequent explosion of the boiler. The want of stays allowed the end plates an alternate flattening and bulging action, which so weakened the angle iron (already too light) that it was unable to stand the pressure. In fact, it was only a matter of time, and not fair wear and tear, when this boiler would be sure to burst. In my opinion, the maker of the boiler was entirely to blame for the explosion, and the consequences resulting therefrom. I am also of opinion that the maker erred from the want of knowledge of the principles of boiler making, as it would not have added more than five per cent. to its original cost to have made it a really good and serviceable boiler.

The bulging and flattening action of the ends had so weakened
and fractured the angle iron at the roots that it at last gave way under pressure, tearing the angle iron in halves as if it had been cut with a knife, one half going with the end, and the other half remaining on the shell of the boiler.

The boiler burst just under the front end, where there were two fractures about thirteen inches long round the root of the angle iron, and which had the appearance of having been there for some time—probably had been increasing gradually until they finally burst; and the sudden relief of pressure caused by this outrush of water, in my opinion, caused the water in the boiler to explode, or flash into steam, instantly blowing out the other end of the boiler.

The owners of the boiler took, as far as they knew, every precaution, as they had it overhauled by a firm of boiler makers only three or four months before the accident, and it was tested to 100lb. per square inch cold water. To all outward appearances, it looked quite safe at 50lb. pressure of steam. None but an expert—and he only after an internal examination—could know the angle irons were too light, and be able to tell that there were no gusset stays at the ends.

Here, again, we have an instance of a defective boiler being tested to twice its working pressure without detecting its defects, but only, in my opinion, hastening its destruction, as it exploded three or four months after, killing one person, injuring six others, and destroying over £2000 worth of property.

The next four explosions were all collapses of flues or furnace crown, caused by shortness of water, by which no person was injured, but about £500 worth of damage was done.

One was at Mr Fraim's marble works, Moray-street, South Melbourne. The flue of a Cornish boiler collapsed through want of water, caused by the gauge-glass not acting properly.

Another of a similar nature occurred at Eaglehawk on the 1st December, 1884, at the United Devonshire Company's claim. The boiler attendant was afterwards tried and found guilty of neglect of duty.

The third and fourth both occurred in Melbourne—one in a brewery, and the other to the furnace crown of the boilers of the steamer Golden Crown.

On the 24th of January of the present year a boiler at one of the mines in Sandhurst exploded with great force, doing over £500 worth of damage to property, but no one was killed, although there were some very narrow escapes.

The boiler, a Cornish one, 33ft. x 6ft., was over 20 years old. The whole of the inner tube collapsed, leaving the outer shell uninjured. The boiler presented a very marked appearance of the stupendous power of pent-up steam. The tube was twisted
and crumpled up into all sorts of fantastic shapes, and although about a quarter of an inch thick, it looked as if it had been gathered up and crammed inside the shell with as much ease as would be required to thrust in a piece of brown paper.

From what information I could gather, there seems to have been plenty of water in the boiler at the time. I have seen an instance of a similar kind which was caused by sediment gathering on the top of the tube to such an extent as to keep the water off the plate, and the impact of the flame made it red-hot, causing collapse.

This boiler was also, in my opinion, tested to too great a hydraulic pressure two or three months before the explosion occurred.

Even boiler-making factories have not been exempt, as a very serious explosion occurred at Johnston's boiler works on the 3rd of March last, when a vertical boiler exploded, by which a young man was killed and another injured, and a considerable amount of damage done to property. Mr. C. M'Lean, engineer, reported at the inquest that, in his opinion, the impact of heat had softened the iron of the upper part of the boiler from want of water, and this led him to believe that the explosion occurred through want of sufficient water in the boiler, and here the enquiry seems to have ended. It was a pity that it did not inquire as to what was the cause, or who was to blame for the want of water.

This explosion provides us with an excellent example of the extraordinary violence of boiler explosions. The question may well be asked why, when the rent occurred on the crown of the boiler, the steam did not relieve itself of the excess of steam pressure. Or, in other words, what is the reason why a boiler, instead of giving away quietly and letting the contents leak out, is torn into fragments? It means the reason why men are slain, houses knocked down, and devastation spread around. The first cause, viz., the weakness of the boiler, has long been studied, and all that need be known is known perhaps about it. It is well known, for example, that a boiler should be carefully and periodically inspected, that supporting a boiler on a longitudinal mid-feather is bad practice, &c. But it is not generally understood why a boiler bursts with violence. Rankin says that in a boiler with pressure to the square inch every cubic foot of water in the 50lb. boiler contains as much explosive energy as a pound of gunpowder, and that if anything occurred to suddenly disturb the equilibrium of the water a shattering explosion would be the result.

Now let us apply this reasoning to the boiler in question. It was a vertical boiler, about 9ft. x 19in. in diameter, and it is variously estimated that it was blown from 100 to 150 feet high.
The weight of the boiler was about 2,500 lb., and the area of the crown 250 square inches. It would require 1,000 foot pounds to every square inch of area to lift it 100 feet. I do not say that this pressure was instantly formed, but I believe a pressure of about 250 lb. to the square inch was instantly raised when the water flashed into steam, which would be too much for most boilers to stand. I am sorry that time will not allow me to treat more fully on this subject, as it shows the great necessity for the factor of safety of boilers being very high.

I may as well, while I think of it, take this opportunity to warn steam users who feed their boilers by Yan Yein pressure to always have a check-valve fitted to their boiler; for, if the pressure in the boiler be highest, it will force all the water back out of the boiler into the pipes. I do not say, or even imply, that such was the case with the boiler just mentioned, as I never saw the boiler, and the owner refused to give the information required; but I have known several instances where the Yan Yein has been laid on to boilers without check-valves, and wish to prevent such fatal mistakes.

Thus we have had for the twelve months twelve boiler explosions, by which four persons were killed, fourteen others injured, and over £6,500 worth of property destroyed.

In five cases shortness of water seems to have been the primary cause. Three explosions were from over-pressure on old and worn-out boilers; three from malconstruction, and one doubtful, but which I think might have been traced to dirt or sediment in the boiler.

As a comparison of the percentage of explosion and number of boilers in Great Britain and this colony for nearly corresponding periods we have the following extraordinary facts:

By the Board of Trade report for the past year there were forty-one boiler explosions, eighteen persons killed, and sixty-two injured; number of boilers, 110,000.

In Victoria there were twelve boiler explosions, four persons killed, fourteen injured; number of boilers, 4,000.

There have, therefore, been, during the past year, in—

Great Britain 1 explosion in every 2,600 boilers
Victoria 1 ,, ,, 330 ,, 
Great Britain 1 person killed ,, 6,090 ,, 
Victoria 1 ,, ,, 1,000 ,, 
Great Britain 1,, injured ,, 1,774 ,, 
Victoria 1 ,, ,, 286 ,, 

We have, therefore, relatively speaking,

Nearly 8 explosions in Victoria to 1 in Britain
Fully 6 persons killed ,, 1 ,, 
,, 6 ,, injured ,, 1
Now, with these facts staring us in the face, are we to go on, and perhaps go from bad to worse?—or shall we, by giving the subject our careful consideration, devise such means as we can to prevent, as far as lies in our power, in future, such disastrous calamities?

Now, the first question that is likely to be asked is how to account for this state of affairs, and I admit that it is not easily answered; but I hope some of the members will be better able to give this information than I am. However, one reason, I think, may account to a certain extent for the neglect of owners of boilers in not paying more attention to their boilers: it is that while the colony was young the boilers were new, and gave no trouble, and we are only now realising the fact that old boilers are dangerous, and require to be very carefully handled, or, as we have seen, very serious consequences may be the result. Another, and I think the principal reason, has been the want of thoroughly efficient and impartial advice, such as the boiler insurance and inspection companies in England supply to steam users. These companies not only supply advice for a very small annual fee, but are continually sending to steam users small pamphlets of instruction for the guidance of their boiler attendants. In fact, these companies are now looked upon as indispensable to the care and good management of steam boilers, as more than half the boilers in Great Britain are under the care and inspection of one or other of the many boiler-insurance and steam-power companies, and I believe it is difficult to sell a second-hand boiler which has not been under the care of a boiler-insurance company, whilst the fact that it has been under their care is a strong recommendation to any purchaser.

I will now endeavour to give a few hints relative to the preservation of steam boilers, with the view of preventing explosions; but, as I have already taken up a considerable amount of your time, I will be as brief as possible, and hope the other members will discuss the subject, for I am sure many of the members are both able and willing to give much valuable and useful information on this important subject.

My first and best advice to all steam users is to have all boilers thoroughly inspected at least once a year by a competent inspector, who should be able to give reliable and impartial advice to the owners. But this inspector should not be in any way connected with any boiler-making or repairing works, or the owner of the boiler may be apt to think that his advice is based by a desire for the work of repairing the boiler, and the inspector of a boiler, like Caesar's wife, should be above suspicion.
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A boiler which is built in brick should never be built on a brick mid-feather, nor have more than five inches of bricks and mortar against any part of the boiler, as it will only be a harbour for water to lodge in and commence the work of destruction. More boilers are ruined by corrosion at the brickwork than by all the other agents of destruction to which boilers are subject. The best way of setting boilers is on cast iron brackets at each end, and iron or pointed fire brick supports along the sides if a very long boiler, or, if a return flue be required, as shown by Fig. 1, which is a section of a Lancashire boiler.

This figure, in conjunction with Fig. 2, shows what, in my opinion, is the best method of staying the flat ends of boilers, and is so plain and clearly shown as to require but little, if any, explanation.

When a boiler is to be blown empty with the view of cleaning, the fires should be drawn, and the pressure of steam not, under any circumstances, to exceed 10 lb. To suddenly open the blow-off cock at 50 lb. or 60 lb. pressure is to court an explosion, the sudden relief of the water causing the disturbing elements in the boiler which always occur before explosion, and great straining of the boiler is the consequence.

Hydraulic tests of old boilers should not exceed the working pressure, and then only in order to ascertain where there are leaks rather than as a criterion of the strength of the shell. These tests are not only misleading, but sometimes, from the excessive pressure, create flaws which ultimately ruin the boiler.

Shortness of water is the cause of a great many explosions and collapse of flues. An intelligent attendant is the best safeguard against this evil, aided by a fire-plug in the furnace crown, and an alarm whistle attached to the boiler.

Safety valves should be so fixed that they cannot be overloaded, and the steam-gauge ought to be periodically tested and corrected.

There is just one more point to which I would call the attention of steam users, viz.:—It often happens that the engine in a factory has to be stopped suddenly and unexpectedly while the fires are in full blaze, and the steam rising rapidly. To prevent this the fireman often throws open the furnace doors. This should never be done, as it is very injurious to the boiler. All that is required is to shut down the damper door and see that the safety valves are right; and when starting the engine again, care should be taken to let the steam slowly into the engine, as by opening the steam valve full the sudden relief of the steam creates the disturbing elements in the boiler which causes explosions, and many explosions have occurred in this way.
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