

Topic No. 3

WHAT CAUSED THE RECENT EPIDEMIC OF CRACKED SIDE SHEETS AND LEAKY STAYBOLTS IN THE FIREBOXES OF MODERN LOCOMOTIVES, WHERE PREVIOUSLY UNDER THE SAME ROAD CONDITIONS AND SAME WATER CONDITIONS, NONE WAS EXPERIENCED?

GEORGE AUSTIN

L. E. HART, Chairman

JOHN HARTHILL

This subject is one that your committee has found to be of vital interest over the majority of railroads in the United States and Canada. In our investigation we have received answers to a questionnaire distributed to nearly every railroad and in every district of the United States, also in Canada.

We received answers to the questionnaire from 17 railroads, with questions and answers as follows:—

- 1.—Q. On what type of locomotive is this trouble most prevalent?
A. Eleven reported Santa Fe, Mountain, Mikado and Pacific types. Six reported no recent trouble.
- 2.—Q. What type of firebox is used?
A. Wide firebox with and without combustion chamber.
- 3.—Q. What is the percentage of air opening in the grate area as compared with the total grate area?
A. Varies 14 percent to 45 percent in the United States; 40 percent to 50 percent on Canadian Pacific.
- 4.—Q. Is locomotive used in freight or passenger service?
A. Nearly all railroads reported in both classes of service.
- 5.—Q. Is locomotive being operated on encrustating-water or foaming-water districts?
A. Reported 11 encrustating, 6 encrustating and foaming-water districts.
- 6.—Q. Is water treatment used?
A. Water treatment 9; part treatment 4; no treatment used 4.
- 7.—Q. What kind of fuel is used in locomotive, oil or coal?
A. Coal 14; oil 1; both oil and coal fuel used, 2.
- 8.—Q. About how long after new work goes in service does this leakage begin?
A. Varies, 10 days to 24 months on eleven railroads reported; practically no trouble on 6 reported.
- 9.—Q. How are the leaks being handled?
A. Staybolts redriven at first appearance; later, bolts renewed until necessary to renew side sheets.

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Write for Bulletin 2011

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- 10.—Q. What boiler compounds are being used; that is anti-encrustating or anti-foaming?
 A. Both are used, depending on water conditions.
- 11.—Q. Do staybolts develop leaks on outside of firebox?
 A. No, except improperly applied bolts.
- 12.—Q. What is the average leaking area on the inside of fireboxes?
 A. In fire line, average about 6 rows of staybolts high.
- 13.—Q. Do the flues leak?
 A. No.
- 14.—Q. Are the flues welded into back sheet?
 A. Practically all reported flues were welded, some the superheaters only.
- 15.—Q. What is the life of the fireboxes and half side sheets?
 A. Varies, fireboxes 5 to 10 years on large power, 10 to 25 years on small power; side sheets, 6 months to 5 years.

Experience in the past has taught us some of the things which will contribute to the failure of side sheets, and we do not believe it justifiable to place the recent epidemic of cracked side sheets to such things as, improperly fitted bolts, thread sizes and form, unclean boilers; for today nearly all railroads are taking every measure of precaution to cure these defects.

Taps and staybolts are gauged for sizes and tolerances, threads are checked for form and size, boilers are being checked and washed out more thoroughly than ever before. We cannot, however, get away from the fact that with long runs and regular operations of locomotives, a schedule for washing boilers, to keep them clean, is imperative.

Unequal expansion is the primary cause of cracked side sheets, the expansion of the firebox sheet is greater than the outside wrapper sheets and, with the staybolt area and sheet and bolt head hammered, the metal has not a homogeneous structure.

Contributing to the unequal expansion, the side sheet is subjected to cold air every time the firebox door is opened and, on stoker fired boilers, the air drawn through the grates is not distributed to any particular part of the firebox for there are holes in the fire and cold air enters fast. On the modern locomotive, the air enters just below the mudring and the current of air flows next to the side sheets, making it necessary to keep a hot fire or heavy body of fuel for the boiler to generate the steam desired of the power.

Another item contributing to cracked side sheets is scale or solids on the sheet on the water side, making it necessary for the sheet to be heated to a higher temperature to produce the steam desired. At the same time, this increases the difference in temperatures of the side and wrapper sheet, making unequal expansion greater.

In studying the questionnaire, it is evident that all railroads are reducing the air openings in the grate, and good results are being obtained, but the grade of fuel must also be considered. If it were possible to equip the traveling power plant (a locomotive) with a closed ash pan and utilize

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forced draft, distributed over the grate area regularly, as required for combustion, and take care of ashes as produced, the question of cold air contributing to cracked sheets would be removed.

The water conditions will have to be handled according to the district wherein railroad obtains the water.

To eliminate cracked side sheets, and prolong the life of fireboxes of modern locomotives, the modern boiler of higher pressure, requires the best attention possible of attainment from the making of the metal, manufacturing of the parts, assembling of them, up to and including all operations of the locomotive after it is built both at terminals and on the road.

The committee appreciates the response from the members for their information on this subject.

(Applause.)

PRESIDENT USHERWOOD: Gentlemen, you have all heard the report of the committee. What is your pleasure?

MR. BROWN: I move it be accepted and opened for discussion.

MR. MOORE: I second the motion.

(The motion was put to a vote and carried that the report be accepted with thanks to the Committee and opened for discussion.)

DISCUSSION

PRESIDENT USHERWOOD: Mr. L. M. Stewart, Gen. Boiler Inspector, Atlantic Coast Line, Waycross, Ga.

MR. STEWART: *Mr. President, Members of the Master Boiler Makers' Association.*

MR. STEWART: I think this is one of the most important topics that is in the program, and I would certainly like to see the members of this association get up here and discuss this subject. Let's see if we can find out these causes.

Most of our trouble has been in stoker fired engines. I believe that where we have shallow fires and there are places on the grates that are not covered with coal, the cold air in the firebox is partly responsible. It is a vital subject to railroads all over the country. I have come in contact with and talked to boiler makers about it, and all of them are having this same trouble. I would like to hear some good discussion on this to see if we can solve this problem.

(Applause.)

PRESIDENT USHERWOOD: Mr. A. E. Brown, General Boiler Foreman, Louisville & Nashville Railroad, South Louisville, Ky.

MR. BROWN: *Mr. President, Gentlemen of the Association.*

I agree with the previous speaker that this is an important subject. It has given all of us trouble no doubt, and it is up to us to find some plan to eliminate if not remedy the evil altogether.

We have been working on this problem for some time on the Louisville & Nashville Railroad. With us it is not a question of staybolt taps, but the fitting of the staybolts and the proper thread on the bolt and in the hole. We are taking particular pains to determine that point. This is the place for us to try to solve it, and I have here our method that I wish to submit to anyone that can find merits in it.

We are applying what is known as a box patch. I will leave this print for anyone who wishes to see it, but I will say gentlemen we are close onto solving this problem, insofar as checks and cracks are concerned, for none have appeared in this specially designed patch, after being in service for two years. These results you will agree we do not get with flat side sheet patches.

PRESIDENT USHERWOOD: Mr. F. C. Reinhart, General Boiler Foreman, A. T. & S. F. Railway, Fort Madison, Ia.

MR. REINHART: I would like to ask the members if they are experiencing any more trouble with staybolt leakage in wide fireboxes, new style, than with the straight side boxes. We have fifteen engines on our territory, the 4101 class; six of them carry 275 pounds of steam pressure and nine carry 220 pounds steam pressure. While the leakage does not seem to be any more extreme in one than the other, still we have engines operating in the same territory under the same conditions and same appliances in every respect, and they do not show as much leakage as engines with wide fireboxes, which show considerable leakage.

In fact, in one of the engines it was necessary to renew the side sheets at 100,000 miles, while with the straight side boxes, an engine will run 500,000 miles before it is necessary to renew the sheets.

(Applause.)

PRESIDENT USHERWOOD: Mr. H. H. Service Supervisor Welding, A. T. & S. F. Ry., Topeka Kans.

MR. SERVICE: I have in mind a particular point on our railroad where I understood that the chemist advised there was no particular change in the water, and road conditions were about the same, and the stays were leaking. At that time we were using only soda ash treatment in the water. They were given about ten days trial to clean up the condition and apparently this treatment was not sufficient.

I believe Mr. Austin, our retired General Boiler Inspector, suggested that they use a compound which was later applied to the boilers, and this staybolt leakage immediately stopped.

He went further on and made a canvass on other parts for the purpose of seeing if the furnace bearers were well lubricated and found that they should be given their freedom for expansion with the large boilers of today. Some of your furnace bearers may be located on the back end, some on the front, or both, and they may be stuck or galded, and that boiler wants to expand and is being resisted. It may be one of the causes which produces these defects, not only in the fireboxes, but also on the hips of the throat sheets.

(Applause.)

PRESIDENT USHERWOOD: Mr. W. J. Murphy, Div. Boiler Foreman, Penn. R. R., Olean, N. Y.

MR. MURPHY: I really am surprised to learn that there had been

an epidemic of cracked side sheets throughout the country. I am just wondering if that condition is not brought about to a great extent by the use of the injector when the fire is dead or the using of the injector after the fire is knocked out of the locomotive. I have reason to believe that this condition will also be aggravated if the expansion pads are not kept operative and properly lubricated.

PRESIDENT USHERWOOD: Mr. Ira J. Pool, District Boiler Inspector, Baltimore & Ohio R. R., Baltimore, Md.

Mr. Pool: I recently saw some good looking locomotives on the C. & O. railroad. I didn't see any cracked side sheets. Maybe Mr. Buffington can give us some good information on this.

PRESIDENT USHERWOOD: Mr. C. W. Buffington, Master Boiler Maker, Chesapeake & Ohio R. R., Richmond, Va.

Mr. C. W. BUFFINGTON: *Mr. President and Gentlemen:*

I didn't expect to say much about the cracked side sheet proposition, or leaky staybolts, but you all know we had the leaky staybolt proposition to contend with when you began forty-five to fifty years ago, and possibly some of you have been at it longer than that. And I expect you are going to continue to have it. I really haven't seen the remedy yet.

I wasn't aware, as somebody else has said, that there was an unusual epidemic of cracked side sheets and I wasn't aware that we had an unusual epidemic of leaky staybolts. That proposition has been with us since I can remember. We have tried a good many things.

One man spoke about the threads of the bolts and the fit of the bolts, and driving the bolt and everything else, but we still have it with us and we are going to have it as long as we have the stoker fired engines. You can get on an engine and when you start out the fellow throws the fire over and he has the grates covered. You run forty or fifty miles and shut the engine off and glide into the station and look into your firebox and your fire is dead. You think possibly there isn't any fire in it, but when you turn the stoker it ignites. It is the difference in temperature that we are up against and I don't see how we are going to overcome it.

In their report the committee spoke about the closed ash pan to utilize a forced draft. That looks pretty good to me. I have been thinking about old fashioned lids being put on the side, and so on, so that it is covered up when the engine comes in from a run.

To my mind, the damage is done principally on the dump track, and better care should be taken of the engine from the time it is turned over to the round house forces until it is back on the road. I am pleased to see long runs because then we are getting mileage and an engine goes through with comparatively reasonable treatment. Nine-tenths of the trouble is on the dump track.

You run a temperature of 1700 to 2400 in the firebox and then turn around and open the firedoor and let the fire run clear down. What can you expect? That is the weakest point, just as we might say with the fire sheet, and so on. You can't build any machine stronger than its weakest point, and that is one of them. Until we get rid of that excessive change of temperature we will still have cracked side sheets. There is no question but that leaky staybolts cause the side sheets to crack. It is with us yet and it is going to stay for sometime.

(Applause.)

PRESIDENT USHERWOOD: Mr. Wm. N. Moore, Gen. Boiler Foreman, Pere Marquette R. R., Grand Rapids, Mich.

Mr. MOORE: *Mr. President, Members of the Master Boiler Makers' Association:*

I have listened with much interest to the discussion on side sheets. We all know it is a live subject. I have gained some very valuable information. However, there is one thought that has been in my mind for months that hasn't been brought out here, and I believe it will be contributory to this subject of cracked side sheets.

I won't admit that there is an epidemic of cracked side sheets, but we have had a condition the last year on our long run locomotives. We are getting our mileage faster and consequently our side sheets give out quicker. I do believe, from my experience, that the primary cause for side sheets cracking is due to increased demand on firebox plates without the increased non-conductor which is water.

We have the U. S. Mikado, built in '18, '19, and '20 with the four and one-half inch mudrings. The temperature was maintained at fifteen to seventeen to eighteen hundred degrees. Today we are maintaining a temperature of twenty-five, twenty-seven, and twenty-eight hundred degrees with the same amount of water on the sheets that we had before.

You have got to admit that the movement of the water is faster and it must be in order to generate the steam, and I believe the solution is increased water space. I think that is the thing that will solve the problem on fireboxes, and especially side sheets.

On our railroad, the Pere Marquette, we began normalizing our plates in January, 1927, a little over three years ago. I was a little reluctant to normalize the side sheets to begin with, but in time I received orders to include side sheets with balance of firebox sheets. We discovered that giving the side sheets the same amount of normalization, which was 1675°, made the sheets a little too flexible. With the increased demand due to heating the firebox with the same amount of water, the side sheets had a tendency to bulge. Therefore the only thing we could do with the same locomotive was to keep the side sheet in a more rigid condition. This we did by changing the normalizing point to 1250° instead of 1675°.

Of course, this is entirely new and we don't know as yet how it will work out, but we have reason to believe that with a normalization point of 1250° on side sheets that we will get better service than with the higher normalization point.

I believe that our railroad is one of the pioneers in normalizing firebox steel. I have talked to quite a number of men familiar with that feature and I am told that we are really pioneers in normalizing plates. It is not an experiment with us so far as the flange plate is concerned. We have proven the fact that it is beneficial. However, in order to prolong the life of side sheets and get the mileage which we are entitled to, I believe the only thing which can be done to effect a permanent cure will be to give us two inches more water, or possibly two and a half or three, on the side sheets. Many of the real modern ones do have that, but I understand that the new power locomotives being built have mudrings up to seven inches thick. If that is the case it will be interesting to watch those to see what kind of a performance they get on side sheets, and I believe that is the solution of the problem of prolonging the life of side sheets.

(Applause.)

PRESIDENT USHERWOOD: Mr. A. F. Stiglmeier, Gen. Boiler Foreman, N. Y. C. R. R., Albany, N. Y.

MR. STIGLMEIER: *Mr. President, Members of the Master Boiler Makers' Association:*

I am really surprised to hear Mr. Murphy say that he did not know that there was an epidemic of cracked side sheets, for understand that they also are applying half side sheets. I wonder why? Am more than sure that if he will visit our railroad, as well as many others he will find that there is an epidemic of cracked side sheets.

Many railroads I understand are renewing sheets after eight (8) months service, and I have found this condition on the railroad that I am connected with. I would like to call to the attention of Mr. Murphy as well as the other members here present of the exhibit the Republic Steel Corp. have at this convention, and if you will visit the same you will see a side sheet of carbon steel that has been in service a very short time and has many cracks at the staybolt holes. What is the cause? That is something I am sure we would all like to know, and also what can be done to prevent them from checking.

We are all aware that on our present day modern power we carry steam gauge pressure anywhere from two hundred to four hundred pounds. On our railroad we use carbon steel in our fireboxes. The brittle range in this carbon steel I understand is 400 to 450. On the water side of the sheet at 200 pounds steam gauge pressure we have a temperature Fahrenheit of 388.0° while at 400 pounds steam gauge pressure we have a temperature Fahrenheit of 450.0°. On the fire side of the sheet in the fire line we have a temperature of say 1700 to 2600 degrees. With the rapid expansion and contraction we have in the fire line at the 1700 to 2600 degree temperature, and the low brittle range in the carbon steel, we cannot expect the sheets to stand up and not check under the conditions I have just mentioned to you.

We must get into a different kind of material. What this should be I am in no position to say. On our railroads we have tried a different steel with little success. Some members will say nickel steel; on this I can give no information. There is so much that enters into the checking of firebox side sheets in the fire line out of staybolt holes.

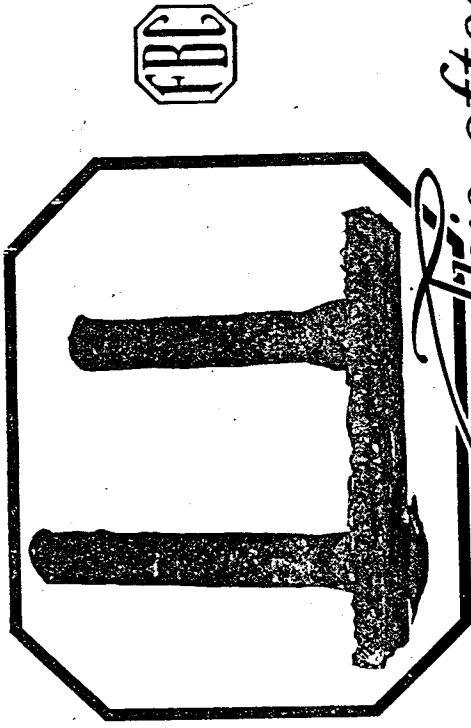
The topic is a little like a pair of shoes, if we wear them much they wear out fast. The same with side sheets, if we carry high steam pressure and pull heavy tonnage trains the sheets give out. And no doubt those of you whose railroads do not carry high steam pressure and have small tonnage trains do not have an epidemic of checked side sheets.

If anyone here has anything to offer to correct conditions mentioned and that will be of benefit to our railroads in solving this problem of checked side sheets we would like to hear from them.

(Applause.)

PRESIDENT USHERWOOD: Mr. Jas. Doran, Gen. Boiler Inspector, A. T. & S. F. Ry., Topeka, Kans.

MR. DORAN: We often have an epidemic of leaky staybolts and so forth but when we have that condition we get after the chemists. I don't care how good work you do; if you haven't got the proper water



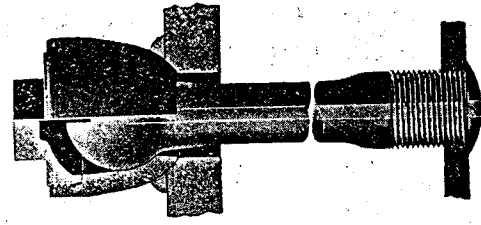
This often happens when you use rigid crown stays

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Crown stay troubles have been attributed to many causes. They are due principally to the lifting action of the crown sheet, which is caused by expansion when the boiler is first fired up, tending to force the sheet upward on the bolt.

As pressure is raised in the boiler, and expansion of the outer shell begins, the crown sheet reverses its movement on the bolt. This action, repeated many times, loosens the bolt fit in the sheet, and eventually causes the threads of both the bolt and sheet to fail.

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conditions they are going to leak, and if soda ash and lime won't prevent their leaking you might try something else.

There are times when we have quite a lot of staybolts leaking, but when we get after the chemists and correct the water treatment it all stops. Then if you have leaking staybolts you are going to have cracked side sheets, and I think that if the management want to spend the money for water treatment and so forth you can overcome a good deal of stay-bolt leakage and also cracked side sheets and it has been, my experience that water conditions are the main cause of staybolt leaking.

PRESIDENT, USHERWOOD: Mr. George Austin, Retired Gen. Boiler Inspector, A. T. & S. F. Ry., Topeka, Kans.

MR. AUSTIN: *Mr. President Members of the Master Boiler Makers' Association:*

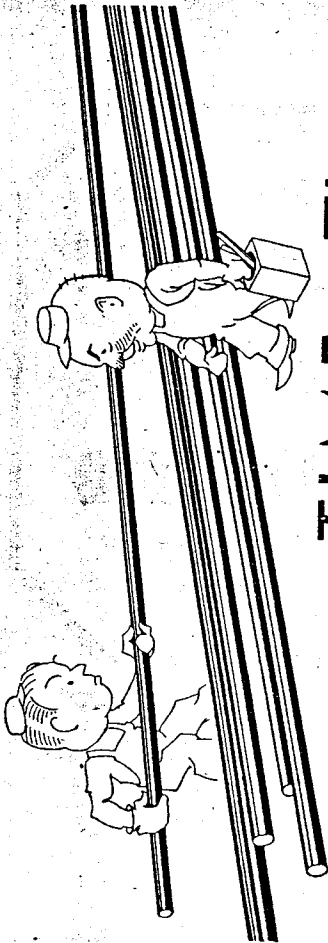
Mr. Doran, to my notion gave the key to the cause of cracked side sheets, pulling cars is the business of a railroad and we pull as many cars and pull them just as fast as any, and we have all kinds of water. We haven't got a gallon of good water on the railroad unless it is made good by water treatment.

The Sante Fe railroad has been treating water for more than thirty years. I have been on the job for twenty-seven years, looking after boilers and studying the effect of water treating and I have had a big field of observation, to judge from as to the benefits of water treatment. The Sante Fe has in the neighborhood of 150 or 160 roadside treating plants and they are still installing others. They have in addition I don't know how many supplemental plants and small treaters to supply that anti-corrosion element. What it is I don't know, but it has greatly improved the condition of corrosion and pitting which formerly existed in locomotives running in territory where incrustation and corrosion gave trouble.

The epidemic of leaky staybolts mentioned in the subject is characteristic of bad water and bad water only. The water may be fairly good water when the engine starts out, but by the time several boilers of water have been evaporated it begins to get bad. It keeps concentrating and getting more unfit for boiler use.

Some are adopting or advocating the use of blow out directly, among other things. I have gone into the matter of blowing out very thoroughly, tested it out in every conceivable way as to the best methods and have decided that we don't get blowing out for nothing. When you are blowing out water that has been heated you are blowing away money. You can't get something for nothing. Now the question is, Does it pay for any railroad to blow away water that has been heated or blow away fuel, or would it pay to spend money to avoid the necessity of wasting this fuel? In other words, does it pay to treat the water?

You may start as they have done on many roads—and we have done so—and adopt water treatment. We are gratified and congratulate ourselves on the improvement made by the introduction of the water treating system. That isn't all. There may be still room for further improvements. It may be just a turn of the hand, a little more water treatment or some other kind of treatment which will develop still more improvement and that is why the Sante Fe have installed so many supplemental and small treating plants, was to improve still further. The same kind of medicine won't do for every kind of disease and the same treatment won't do for every water you have on the railroad. You



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have to adjust the water to your requirements to get the best results. Some waters will mix; some won't mix, and you only cause trouble to try to mix some waters. You may take water at one station and up to that time the water that has been carried in the boiler hasn't given any trouble; but mixing the water and it acts like sidletz powder, up she goes.

This question of leaky staybolts applies to leaks in the whole boiler and all the boilers on every railroad, and it means that the boiler is trying to tell you that there is something wrong. It is either the boiler water or improper drafting; one or both these conditions. Generally it is the water.

When we find a bunch of bolts leaking in one side sheet, what is the use of saying that is all water? There is an evidence of improper drafting. Suppose we find staybolts leaking up in the top of the door sheets; what is the use of calling that water? That is poor drafting. The engine is trying to tell you what is wrong.

We have put in hot water plants and we do that so that we will avoid the necessity of setting up stresses due to unequal temperatures at various parts of boilers, and yet I have found the hot water plant delivering cold water instead of hot, and find them blowing out hot boilers and filling them again with water at 72°. In these cases the hot boiler washing plant was being poorly looked after it looked as if no one was paying any attention to it. I am just mentioning that as one of the things that is contributory to leaky staybolts.

Your locomotive engineman, when he applies the injector and puts in four to six or eight inches while standing still, is another cause of leaky staybolts. Having the blower on doesn't do any good. When he has the blower on he maintains the top temperature, and the steam pressure, but the lower part of the boiler is cooling off just the same, and if you watch the operation you will see as that water comes up it contracts the sheet below and buckles the sheet above, and the top holes start to leak.

Allowing deep beds of clinkers to form on the grates is another cause for leaky staybolts, there is no circulation below the top of the bed of ashes, and the lower firebox sheets are badly stressed because of being at low temperature.

These troubles have existed ever since we have been running boilers and they will continue to exist until we are educated to the fact that it pays to furnish the best kind of water for boiler use.

(Applause.)

PRESIDENT USHERWOOD: Mr. B. F. Andre, General Boiler Foreman, Chesapeake & Ohio R. R., Ashland, Ky.

MR. ANDRE: Mr. President and Members of the Master Boiler Makers' Association: While talking about leaky staybolts, I have a little thought that I want to drop that may be beneficial to all of you. I have worked along the Ohio River for twenty-four years. I am now working on the Chesapeake & Ohio, and they have adopted the blow-off system. I am going to mention one engine in particular to which they have applied the blow off system.

They had a mechanical inspector ride this engine to see that it was blown off regularly as per instructions from the chemists. That engine was run thirty days, to my knowledge, and when it came into the round house for a washout, we didn't get a teaspoonful of sediment out of that

boiler. I believe Mr. Buffington will substantiate that statement.

I have watched that boiler continuously for the length of time it has been in service, about twelve months, and I have noticed the staybolts. I don't find any sediment or scale gathered around the inside sheet. That engine is running in a territory where we have been directly bothered with leaky staybolts, and I will say we haven't had a hammer on a staybolt in that engine since it has been out of the shop, and we contribute that to the blowing out directly and keeping it clean. If you keep the boiler thoroughly blown out and keep the scale from accumulating on the side sheet, you will eliminate leaky staybolts.

(Applause.)

PRESIDENT USHERWOOD: We would like to devote more time to the discussion of this subject. However, we are somewhat behind with our schedule and I will declare the topic closed.

PRESIDENT USHERWOOD: Topic No. 4 is next on the program: "What is the most economical method of repairing cracked mud rings or corners, without removing the ring; also the best method of keeping corners tight?" The committee consists of Mr. W. N. Moore, Chairman, Mr. E. J. Reardon, and Mr. John Clas.

PRESIDENT USHERWOOD: Mr. W. M. Moore, General Boiler Foreman, Pere Marquette R. R., Grand Rapids, Mich. Will read the committee report on topic No. 4.

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